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AUTHORITY

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IDEP FORM NO 17:10-62 IDEP

GENERAL REPORT SUMMARY SHEET

1 OF 1

1. COMPONENT/PART NAME PER GENERIC CODE	2. PROGRAM OR WEAPON SYSTEM	3	DAY	MO	YR.
Antennas-Radio, Command & Telemetering, Fixed Position, 3000, 30,000 MC SHF	Apollo	TEST COMPL.	15	2	66
4. ORIGINATOR'S PART NAME	5. ORIGINATOR'S REPORT NO	REPT COMPL.		5	66
Apollo Beacon Antennas	DTR-81				
	6. TEST TYPE, ETC.				
	Development				

25141

7 THIS TEST ~~(SUPERSEDES)~~ (SUPPLEMENTS) REPORT NO: 081.50.70.00-F1-02S (MC481-0005)

8. OUTLINE, TABLE OF CONTENTS, SUMMARY, OR EQUIVALENT DESCRIPTION:

MFGR: Amecon, Division of Litton Industries

(11) May 66

(10) I. Freedman (12) 377 p.

SCOPE

The tests ~~herein~~ reported were undertaken as part of a comprehensive program to prove the design of a C-Band Beacon Antenna and to determine its capability of performing its primary mission during subjection to the environmental stresses to be encountered by an earth-moon-earth vehicle.

TEST PROCEDURES

Connector Breakdown Under Radiation, High Altitude and High Power Condition Test

Corona Discharge Test

Sinusoidal Vibration Test

Combined Vibration and High Temperature Test

Sand and Dust Test

Helium Leak Test

Off-Limits Vibration Test

Acoustic Test

Antenna to Backcap Bond Test

Combined Vibration and High Low Temperature Test

Humidity Test

Random Vibration Test

Compression Tests

Thermal Shock Test No. 1

Thermal Shock Test No. 2

3 AUG 1966

(18) IDEP

(17) REPT NO 081.50.70.00-F1-03

The Antennas Tested met all specifications and are acceptable for the intended function.

9. SIGNATURE I. Jurist

10. CONTRACTOR NAA/S&ID SUBCONTRACTOR

(328 366)

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NOTICES PAGE

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DTR-01

AMECOM
DIVISION OF LITTON INDUSTRIES

DEVELOPMENT TEST REPORT

ON

APOLLO BEACON ANTENNAS

MAY 1966

Prepared Under

NAA/S&ID Contract No. M4J3XAA-425006A

1140 EAST-WEST HIGHWAY
SILVER SPRING, MARYLAND
301-588-7273

AMECOM
LITTON SYSTEMS, INC.

LITTON INDUSTRIES • AMECOM DIVISION • 1140 EAST-WEST HIGHWAY • SILVER SPRING, MARYLAND 20910 • (301) 588-7273 • TWX 301-439-4905

19 July 1966

North American Aviation, Inc.
Space and Information Systems Division
12214 Lakewood Boulevard
Downey, California

Attention: Mr. I. Jurist

Gentlemen:

In response to your letter, dated July 14, 1966, pertaining to the submission of Report Number 081.50.70.00-F1-02S (MC481-0005) to the Interservice Data Exchange Program (IDEP). The report was reviewed by the reliability personnel of AMECOM and found to be accurate and complete in content. AMECOM is pleased to be a contributor to the Interservice Data Exchange Program, and will be pleased to furnish any additional information.

Very truly yours,

AMECOM Division

Ernest L. Stepp
E. L. Stepp
Section Manager,
Reliability & Environmental Section

/pm

AMECOM
DIVISION OF LITTON INDUSTRIES

DEVELOPMENT TEST REPORT

ON

APOLLO BEACON ANTENNAS

MAY 1966

Prepared Under

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1140 EAST-WEST HIGHWAY
SILVER SPRING, MARYLAND
301-588-7273

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LIST OF ILLUSTRATIONS, (Continued)

LIST OF ILLUSTRATIONS, (Continued)

DEVELOPMENT TEST REPORT

FOR THE

APOLLO BEACON ANTENNA

1.0 SCOPE

The tests herein reported were undertaken as part of a comprehensive program to prove the design of a C-Band Beacon Antenna and to determine its capability of performing its primary mission during subjection to the environmental stresses to be encountered by an earth-moon-earth vehicle.

2.0 TEST PROCEDURES

2.1 Connector Breakdown Under Radiation, High Altitude and High Power Condition Test

2.1.1 General

2.1.1.1 One of the first problems encountered as a result of the investigations conducted by the Litton Reliability group was the possibility of arcing within the antenna connector as a result of operation at high R.F. power levels at elevated altitudes with concurrent bombardment by high energy sub atomic particles. The high altitude, high voltage breakdown phenomenon in air under pulsed conditions is a function of four variables. These variables are frequency, pulse width, pressure and applied voltage. The first two of these variables, frequency and pulse width, are fixed in this antenna. Therefore, pressure and applied voltage were the two parameters varied to determine the breakdown characteristics of the "TNC" connector.

2.1.1.2 At a specific pressure, with the frequency fixed, the mean free time will be such that the frequency of collision between free electron and gas atom is equal to the frequency of the applied field. This is approximately the pressure at which minimum voltage is required for breakdown. This specific pressure is called the critical pressure. It is possible to remain at this critical pressure and at the corresponding critical voltage without the occurrence of breakdown. Without some initial free electrons to be accelerated by the R.F. field, breakdown cannot proceed. Breakdown within the connector is occasioned by the occurrence of an ion pair during the time an R.F. pulse exists. Since the ions are very short lived, this coincidence of events is necessary. An ion pair can be generated by a radiation particle colliding with a gas molecule. The chances of such a collision are low and of a random nature. As the dose rate increases, so does the number of radiation particles and so does the probability of a collision.

2.1.1.3 During this test program, a radiation source was employed to provide the initial ions necessary to initiate the breakdown sequence. This radiation source was of sufficient size to provide the initial ionization of any gas within the connector, but far below the radiation level which could cause any radiation damage to the materials within the connector.

Since the primary objective of this test was to determine the suitability of this connector for use in the Apollo Beacon Antenna, attempts were made to modify the connector and isolate the area of breakdown. Most of the tests during this program were performed at critical altitude and maximum required peak power using various configurations of the "TNC" connector.

2.1.2 Laboratory Conditions

2.1.2.1 These tests were performed at prevailing laboratory temperature and humidity.

2.1.3 Definition of Breakdown

2.1.3.1 Electrical breakdown or discharge through the air gap of the connector is herein defined as any decrease in amplitude of the pulse as observed on an oscilloscope.

2.1.4 Frequency

2.1.4.1 The input frequency to the connector under test was 5.64Kmc. The pulse duration was .75 microseconds and the P.R.F. was 1000 pulses per second.

2.1.5 Power

2.1.5.1 The input power to the connector under test was 3 kilowatts (peak) at the pulse duration and P.R.F. listed above.

2.1.6 Test Equipment

Vacuum Chamber	- See Figure 1
5000 Curie Source	- Cobalt 60
Gamma Laboratory Test Chamber	- University of Maryland Nuclear Eng. Department
1KC Square Wave Modulator	- Antlab Modulator 7206
.275 Megawatt Modulator	- Manson Labs.
Magnetron	- QK456
Isolator	- Type 1205
Full "E" Adaptor	- Type 6281A
RG 9 B/U Cable	- 100 Feet
30 DB Pad	-
Crystal Detector	- PRD 621A
Resistor	- 1,000 ohm
Scope	- Textronix Type 531
Variable Attenuator	- HP 632A
Power Meter	- HP 430C

2.1.7 Test Procedure

2.1.7.1 The vacuum chamber was installed in the Gamma Laboratory Test chamber and the connector was placed as shown in Figure 1. Test readings were then taken under the following conditions:

	Pressure	Power	Radiation
1.	Atmospheric	3000 watts peak	None
2.	760 Microns	3000 watts peak	None
3.	760 Microns	3000 watts peak	19 mR/hr to 480 R/hr
4.	760 Microns	3000 watts peak	None
5.	Atmospheric	3000 watts peak	None

2.1.7.2 When breakdown occurred, a slightly modified connector would be inserted and the test re-run. This was repeated for each of the seven different connector configurations listed below:

1. Normal TNC connectors - No modifications
2. Normal TNC connectors - Silicone grease packed in air gap of feed-through connectors at vacuum plate.
3. TNC packed with silicone grease in the cable entry area and at feed-through air gap.
4. Hole in mating center connectors, TNC packed with silicone grease in the cable entry and at feed-through air gap.
5. TNC cable entry area filled with RTV, hole in center connector pair, silicone grease packed in feed-through air gap.
6. Modified teflon insert, cable entry area and feed-through air gap packed with silicone grease, hole in center connector pair.
7. TNC cable entry area filled with RTV, modified teflon insert, feed-through air gap packed with silicone grease, hole in center connector pair.

2.1.7.3 Four radiation levels were used during the test phase:

1. 19 mR/hr
2. 750 mR/hr
3. 2.4 R/hr
4. 480 R/hr

2.1.8 Test Results

2.1.8.1 Configuration #1 (normal TNC connectors-no modifications). Breakdown occurred at 1250 watts without a radiation source at a pressure of 700 microns. Evidence of breakdown in the feed-through input connector was observed. This breakdown was from the center conductor to the outer shield. Slight burning was also noted on the center conductor of the center connector pair. Approximately 75% of the pulse amplitude was lost during breakdown.

2.1.8.2 Configuration #2 (normal TNC connectors - silicone grease packed in air gap of feed-through connectors at vacuum plate)-- Breakdown occurred at full power at a pressure of 750 microns with a radiation dose rate of 2.4 R/hr. The breakdown was intermittent in nature due to the relatively low radiation dose rate. Approximately 50% of the pulse amplitude was lost during breakdown.

2.1.8.3 Configuration #3 (TNC packed with silicone grease in the cable entry area and at the feed-through air gap)-- No breakdown occurred with this configuration at low (2.4 R/hr.) and high (480 R/hr.) radiation levels. It was believed that air was trapped within the connector at atmospheric pressure and therefore critical altitude was not achieved.

2.1.8.4 Configuration #4 (hole in mating center connectors, TNC packed with silicone grease in cable entry area and at feed-through air gap)-- Breakdown occurred at a radiation level of 480 R/hr. thus verifying the presence of trapped air in Configuration #3. Approximately 25% of the pulse amplitude was lost during breakdown. Additional tests were performed using this configuration, and varying only the radiation level. At a dose rate of 19 mR/hr., no breakdown was observed. The radiation level was then increased to 750 mR/hr. At this level, breakdown occurred in a very random fashion. Next, the radiation level was increased to 480 R/hr. At this level, constant breakdown occurred. These results tend to verify the theory that the time to breakdown is decreased with increased radiation. It is believed that breakdown was occurring with the 19 mR/hr. source; however, it was so intermittent that it was not observable on the scope.

2.1.8.5 Configuration #5 (TNC cable entry area filled with RTV, hole in center connector pair, silicone grease packed in feed-through air gap)-- Breakdown occurred at a radiation dose rate of 480 R/hr. at a pressure of 750 microns and a power level of 3000 watts. The pressure was then increased to atmospheric and decreased to 35 microns and under the same conditions of power and radiation. No breakdown occurred. This indicates that the area involved in breakdown is pressure dependent.

2.1.8.6 Configuration #6 (modified teflon insert, cable entry area and feed-through air gap packed with silicone grease, hole in center connector pair)-- Breakdown occurred at a radiation dose rate of .75 and 480 R/hr. at a pressure of 760 microns and a power level of 3000 watts. Approximately 25% of the pulse amplitude was lost during breakdown.

2.1.8.7 Configuration #7 (TNC cable entry area filled with RTV, modified teflon insert, feed-through air gap packed with silicone grease, hole in center connector pair)-- The first connector tested using this configuration did not break down under any conditions of radiation, pressure and power. The power level was increased to 6000 watts while at a pressure of 760 microns and a radiation dose rate of 480 R/hr. without breakdown. Three further tests were performed with different connector sets and breakdown occurred during all three tests. Breakdown occurred at a pressure of 760 microns, a power level of 3000 watts and a radiation dose rate of 480 R/hr. Approximately 5 to 10% of the pulse amplitude was lost during breakdown in each of these connector sets.

2.1.9 Conclusions

2.1.9.1 The following conclusions were reached as a result of this test program:

1. A modified "TNC" connector is acceptable for use in the Apollo Beacon Antenna.
2. The cable entry area of the "TNC" connector should be potted with RTV compound.
3. A small air path should be provided through the outer shield of the connector pair to allow pressure equalization within the connector pair.
4. The teflon insulation in the female "TNC" should be modified to provide an interference fit at all surfaces with the male "TNC".
5. The teflon insulation in the pin feed-through area of both male and female "TNC" should provide an interference fit with the pin and cable conductor sleeving.
6. The teflon insulation in the pin feed-through area should be extended back through the metal washer at the cable entry area of both male and female "TNC".
7. A teflon sleeve should be placed around the back end of the male connector pin and potted at the end closest to the cable entry area. The outer diameter of this sleeve should be the same as the center cable conductor sleeve.

8. A teflon sleeve should be placed around the female connector pin and potted at the end closest to the cable entry area. The outer diameter of this sleeve should be the same as the center cable conductor sleeve.

2.1.10 Test Data

2.1.10.1 The Test Data obtained while running these tests are tabulated on Test Data Sheets 1 thru 19.

Failure Mode and Effect Analysis Test - Connector Breakdown - ARC Discharge

CONFIGURATION # 1 NORMAL TNC CONNECTOR - NO MODIFICATIONS					Date 25 March 1964 Test Data, Sheet 1
Condition	Pressure	Rad. Dose Rate	Power (Peak)	Breakdown	Remarks
1	Atmosphere	None	3000 Watts	No	
2	800 Microns	None	3000 Watts	No	
3	800 Microns	2.4 R/hr	1250 Watts	Yes	
4	800 Microns	None	1250 Watts	Yes	
5	Atmosphere	None	3000 Watts	No	
6	800 Microns	None	1250 Watts	Yes	

Failure Mode and Effect Analysis Test - Connector Breakdown - ARC Discharge

CONFIGURATION #1 NORMAL TNC CONNECTOR - NO MODIFICATIONS

Date 30 March 1964

Test Data, Sheet 2

Condition	Pressure	Rad. Dose Rate	Power (Peak)	Breakdown	Remarks
1	Atmosphere	None	3000 Watts	No	
2	700 Microns	None	1250 Watts	Yes	
3	Atmosphere	None	3000 Watts	No	

Failure Mode and Effect Analysis Test - Connector Breakdown - ARC Discharge

CONFIGURATION # 1 NORMAL TNC CONNECTOR - NO MODIFICATIONS

Date 30 March 1964

Test Data, Sheet 3

Condition	Pressure	Rad. Dose Rate	Power (Peak)	Breakdown	Remarks
1	Atmosphere	None	3000 Watts	No	
2	700 Microns	None	1250 Watts	Yes	
3	Atmosphere	None	3000 Watts	No	
4	Atmos. to 700 Microns	None	3000 Watts	Yes	
5	700 Microns	None	3000 Watts	Yes	Remained at breakdown for a 10 minute period to establish arc point.
6	Atmosphere	None	3000 Watts	No	

Failure Mode and Effect Analysis Test - Connector Breakdown - ARC Discharge

CONFIGURATION #1 NORMAL TNC CONNECTOR - NO MODIFICATION

Date 1 April 1964

Test Data, Sheet 4

Condition	Pressure	Rad. Dose Rate	Power (Peak)	Breakdown	Remarks
1	Atmosphere	None	3000 Watts	No	
2	750 Microns	None	3000 Watts	Yes	75% loss in amplitude
3	750 Microns	480 R/hr	3000 Watts	Yes	75% loss in amplitude
4	Atmosphere	None	3000 Watts	No	

Failure Mode and Effect Analysis Test - Connector Breakdown - ARC Discharge

CONFIGURATION # 2 FEED-THROUGH CONNECTOR AIR GAPS FILLED WITH SILICONE GREASE

Date 31 March 1964

Test Data, Sheet 5

Condition	Pressure	Rad. Dose Rate	Power (Peak)	Breakdown	Remarks
1	Atmosphere	None	3000 Watts	No	
2	750 Microns	None	3000 Watts	No	
3	125 Microns	None	3000 Watts	No	
4	Atmosphere	None	3000 Watts	No	

Failure Mode and Effect Analysis Test - Connector Breakdown - ARC Discharge

CONFIGURATION # 2 FEED-THROUGH CONNECTOR AIR GAPS FILLED WITH SILICONE GREASE

Date 31 March 1964

Test Data, Sheet 6

Condition	Pressure	Rad. Dose Rate	Power (Peak)	Breakdown	Remarks
1	Atmosphere	None	3000 Watts	No	
2	750 Microns	None	3000 Watts	No	
3	750 Microns	2.4 R/hr	3000 Watts	Yes	Breakdown random in nature
4	Atmosphere	None	3000 Watts	No	
5	750 Microns	None	3000 Watts	No	
6	750 Microns	2.4 R/hr	3000 Watts	Yes	Breakdown random in nature
7	Atmosphere	None	3000 Watts	No	

Failure Mode and Effect Analysis Test - Connector Breakdown - ARC Discharge

CONFIGURATION # 3 FEED-THROUGH CONNECTOR AIR GAP AND ALL CABLE ENTRY AREAS FILLED WITH SILICONE GREASE

Date 31 March 1964

Test Data, Sheet 7

Condition	Pressure	Rad. Dose Rate	Power (Peak)	Breakdown	Remarks
1	Atmosphere	None	3000 Watts	No	
2	750 Microns	None	3000 Watts	No	
3	750 Microns	2.4 R/hr	3000 Watts	No	
4	Atmosphere	None	3000 Watts	No	

Failure Mode and Effect Analysis Test - Connector Breakdown - ARC Discharge

CONFIGURATION # 3 FEED-THROUGH CONNECTOR AIR GAP AND ALL CABLE ENTRY AREAS FILLED WITH SILICONE GREASE

Date 31 March 1964

Test Data, Sheet 8

Condition	Pressure	Rad. Dose Rate	Power (Peak)	Breakdown	Remarks
1	Atmosphere to 450 Microns	2.4 R/hr	3000 Watts	No	
2	450 to 150 Microns	2.4 R/hr	3000 Watts	No	
3	Atmosphere	None	3000 Watts	No	

Failure Mode and Effect Analysis Test - Connector Breakdown - ARC Discharge

CONFIGURATION # 3 FEED-THROUGH CONNECTOR AIR GAP AND ALL CABLE ENTRY AREAS FILLED WITH SILICONE GREASE

Date 31 March 1964

Test Data, Sheet 9

Condition	Pressure	Rad. Dose Rate	Power (Peak)	Breakdown	Remarks
1	Atmosphere	None	3000 Watts	No	
2	750 Microns	None	3000 Watts	No	
3	750 Microns	480 R/hr	3000 Watts	No	
4	Atmosphere	None	3000 Watts	No	

Failure Mode and Effect Analysis Test - Connector Breakdown - ARC Discharge

CONFIGURATION # 4 HOLE IN CENTER CONNECTOR PAIR - FEED-THROUGH CONNECTOR AIR GAP AND ALL CABLE ENTRY AREAS FILLED WITH SILICONE GREASE

Date 1 April 1964

Test Data, Sheet 10

Condition	Pressure	Rad. Dose Rate	Power (Peak)	Breakdown	Remarks
1	Atmosphere	None	3000 Watts	No	
2	750 Microns	None	3000 Watts	No	
3	750 Microns	480 R/hr	3000 Watts	Yes	Pressure at end of Condition 900 microns .25% loss in amplitude
4	Atmosphere	None	3000 Watts	No	

Failure Mode and Effect Analysis Test - Connector Breakdown - ARC Discharge

CONFIGURATION # 4 HOLE IN CENTER CONNECTOR PAIR - FEED-THROUGH CONNECTOR AIR GAP AND ALL CABLE ENTRY AREAS FILLED WITH SILICONE GREASE

Date 1 April 1964

Test Data, Sheet 11

Condition	Pressure	Rad. Dose Rate	Power (Peak)	Breakdown	Remarks
1	Atmosphere	None	3000 Watts	No	
2	750 Microns	None	3000 Watts	No	
3	750 Microns	480 R/hr	3000 Watts	Yes	25% loss in amplitude
4	Atmosphere	None	3000 Watts	No	

Failure Mode and Effect Analysis Test - Connector Breakdown - ARC Discharge

CONFIGURATION # 4 HOLE IN CENTER CONNECTOR PAIR - FEED-THROUGH CONNECTOR AIR GAP AND ALL CABLE ENTRY AREAS FILLED WITH SILICONE GREASE

Date 2 April 1964

Test Data, Sheet 12

Condition	Pressure	Rad. Dose Rate	Power (Peak)	Breakdown	Remarks
1	Atmosphere	None	3000 Watts	No	
2	Atmosphere to 750 Microns	19 mR/hr	3000 Watts	No	Stronium 90 source
3	750 Microns	19 mR/hr	3000 Watts	No	
4	Atmosphere	None	3000 Watts	No	

Failure Mode and Effect Analysis Test - Connector Breakdown - ARC Discharge

CONFIGURATION # 4 HOLE IN CENTER CONNECTOR PAIR - FEED-THROUGH CONNECTOR AIR GAP AND ALL CABLE ENTRY AREAS FILLED WITH SILICONE GREASE

Date 2 April 1964

Test Data, Sheet 13

Condition	Pressure	Rad. Dose Rate	Power (Peak)	Breakdown	Remarks
1	Atmosphere	None	3000 Watts	No	
2	Atmosphere to 750 Microns	None	3000 Watts	No	
3	750 Microns	750 mR/hr	3000 Watts	Yes	Breakdown random in nature
4	750 Microns	480 R/hr	3000 Watts	Yes	25% loss in amplitude
5	750 Microns	None	3000 Watts	No	
6	Atmosphere	None	3000 Watts	No	

Failure Mode and Effect Analysis Test - Connector Breakdown - ARC Discharge

CONFIGURATION # 5 ALL CABLE ENTRY AREAS FILLED WITH RTV - HOLE IN CENTER CONNECTOR PAIR - FEED-THROUGH CONNECTOR AIR GAP FILLED WITH SILICONE GREASE

Date 3 April 1964

Test Data, Sheet 14

Condition	Pressure	Rad. Dose Rate	Power (Peak)	Breakdown	Remarks
1	Atmosphere	None	3000 Watts	No	
2	Atmosphere to 35 Microns	None	3000 Watts	No	
3	35 Microns	480 R/hr	3000 Watts	No	
4	750 Microns	None	3000 Watts	No	
5	750 Microns	480 R/hr	3000 Watts	Yes	20% loss in amplitude
6	750 Microns	480 R/hr	5000 Watts	Yes	20% loss in amplitude
7	Atmosphere	None	3000 Watts	No	

Failure Mode and Effect Analysis Test - Connector Breakdown - ARC Discharge					
CONFIGURATION #6 MODIFIED TEFLON INSERT - HOLE IN CENTER CONNECTOR PAIR - SILICONE GREASE IN ALL CABLE ENTRY AREAS AND AT FEED-THROUGH CONNECTOR					Date 4 April 1964 Test Data, Sheet 15
Condition	**Pressure**	**Rad. Dose Rate**	**Power (Peak)**	**Breakdown**	**Remarks**
1	Atmosphere	None	3000 Watts	No	
2	Atmosphere to 750 Microns	None	3000 Watts	No	
3	750 Microns	.75 R/hr	3000 Watts	Yes	Breakdown random in nature 25% loss in amplitude
4	750 Microns	480 R/hr	3000 Watts	Yes	25% loss in amplitude
5	Atmosphere	None	3000 Watts	No	

Failure Mode and Effect Analysis Test - Connector Breakdown - ARC Discharge

CONFIGURATION # 7 MODIFIED TEFLON INSERT - HOLE IN CENTER CONNECTOR PAIR - RTV IN ALL CABLE ENTRY AREAS - SILICONE GREASE FILLED FEED-THROUGH CONNECTOR

Date 4 April 1964

Test Data, Sheet 16

Condition	Pressure	Rad. Dose Rate	Power (Peak)	Breakdown	Remarks
1	Atmosphere	None	3000 Watts	No	
2	Atmosphere to 750 Microns	None	3000 Watts	No	
3	750 Microns	.75 R/hr	3000 Watts	No	
4	750 Microns	480 R/hr	3000 Watts	No	
5	750 Microns	480 R/hr	6000 Watts	No	
6	Atmosphere	None	3000 Watts	No	

Failure Mode and Effect Analysis Test - Connector Breakdown - ARC Discharge

CONFIGURATION # 7 MODIFIED TEFLON INSERT - HOLE IN CENTER CONNECTOR PAIR - RTV IN ALL CABLE ENTRY AREAS - SILICONE GREASE FILLED FEED-THROUGH CONNECTOR

Date 4 April 1964

Test Data, Sheet 17

Condition	Pressure	Rad. Dose Rate	Power (Peak)	Breakdown	Remarks
1	Atmosphere	None	3000 Watts	No	
2	Atmosphere to 50 Microns	None	3000 Watts	No	
3	750 Microns	None	3000 Watts	No	
4	750 Microns	.75 R/hr	3000 Watts	No	
5	750 Microns	480 R/hr	3000 Watts	Yes	5 to 10% loss in amplitude
6	750 Microns	480 R/hr	6000 Watts	Yes	5 to 10% loss in amplitude
7	750 Microns	None	3000 Watts	Yes	5 to 10% loss in amplitude
8	750 Microns	None	6000 Watts	Yes	5 to 10% loss in amplitude
9	Atmosphere	None	3000 Watts	No	
10	Atmosphere	None	6000 Watts	No	

Failure Mode and Effect Analysis Test - Connector Breakdown - ARC Discharge

CONFIGURATION # 7 MODIFIED TEFLON INSERT - HOLE IN CENTER CONNECTOR PAIR - RTV IN ALL CABLE ENTRY AREAS - SILICONE GREASE FILLED FEED-THROUGH CONNECTORS

Date 4 April 1964

Test Data, Sheet 18

Condition	Pressure	Rad. Dose Rate	Power (Peak)	Breakdown	Remarks
1	Atmosphere	None	3000 Watts	No	
2	750 Microns	None	3000 Watts	No	
3	750 Microns	480 R/hr	3000 Watts	No	
4	750 Microns	480 R/hr	6000 Watts	Yes	Breakdown random in nature 5 to 10% loss in amplitude
5	750 Microns	None	6000 Watts	No	
6	750 Microns	480 R/hr	3000 Watts	No	
7	Atmosphere	None	3000 Watts	No	

Failure Mode and Effect Analysis Test - Connector Breakdown - ARC Discharge

CONFIGURATION # 7 MODIFIED TEFLON INSERT - HOLD IN CENTER CONNECTOR PAIR - RTV IN ALL CABLE ENTRY AREAS - SILICONE GREASE FILLED FEED-THROUGH CONNECTORS

Date 4 April 1964

Test Data, Sheet 19

Condition	Pressure	Rad. Dose Rate	Power (Peak)	Breakdown	Remarks
1	Atmosphere	None	3000 Watts	No	
2	750 Microns	None	3000 Watts	No	
3	750 Microns	.75 R/hr	3000 Watts	No	
4	750 Microns	480 R/hr	3000 Watts	Yes	Breakdown random in nature 5 to 10% loss in amplitude
5	Atmosphere	None	3000 Watts	No	
6	750 Microns	480 R/hr	3000 Watts	Yes	5 to 10% loss in amplitude
7	Atmosphere	None	3000 Watts	No	

2.1.13 Illustrations

2.1.13.1 Various test set-ups and equipments used in these tests are shown in Figures 1 thru 11.

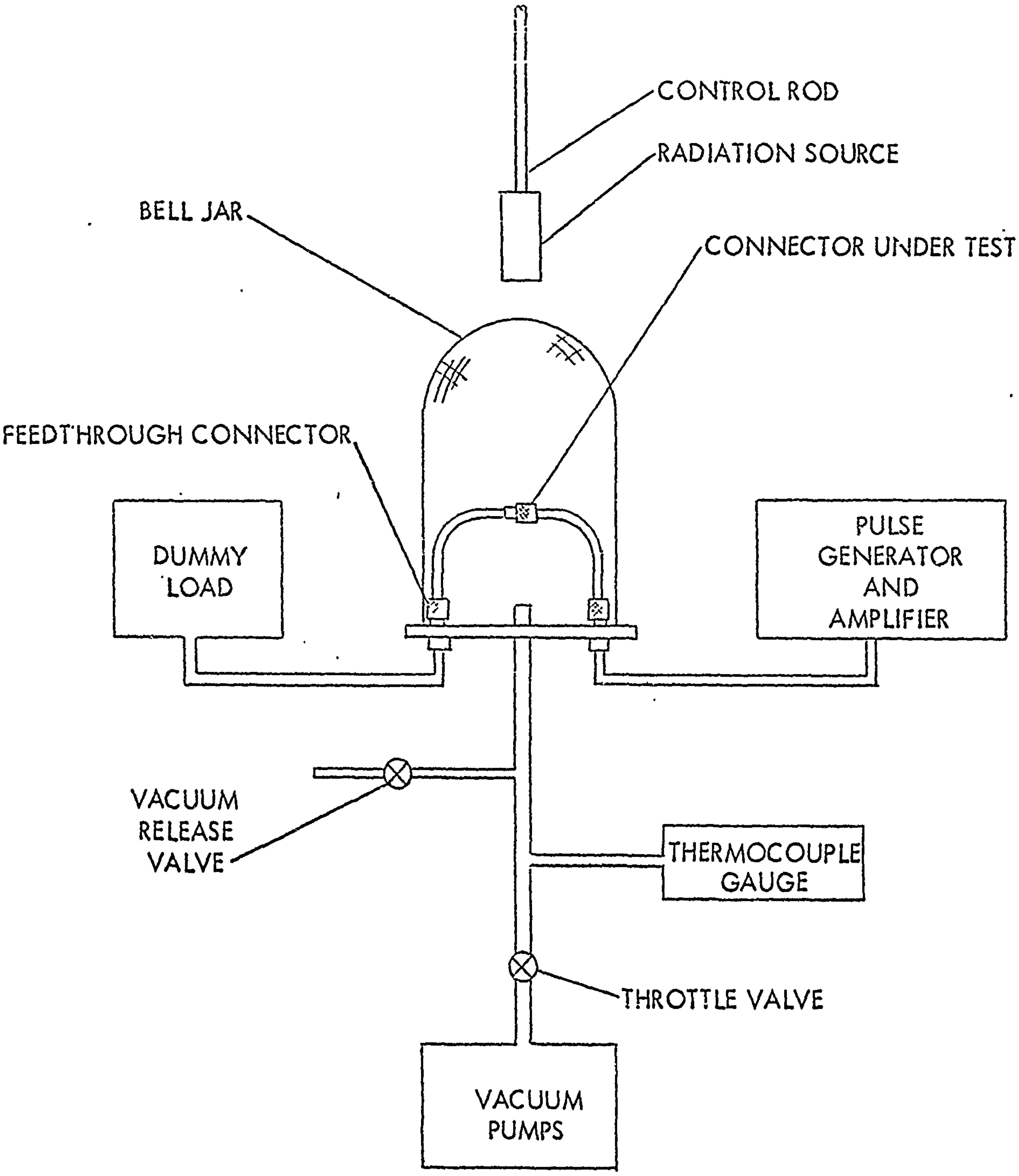

Figure 1. Radiation Test Set-up

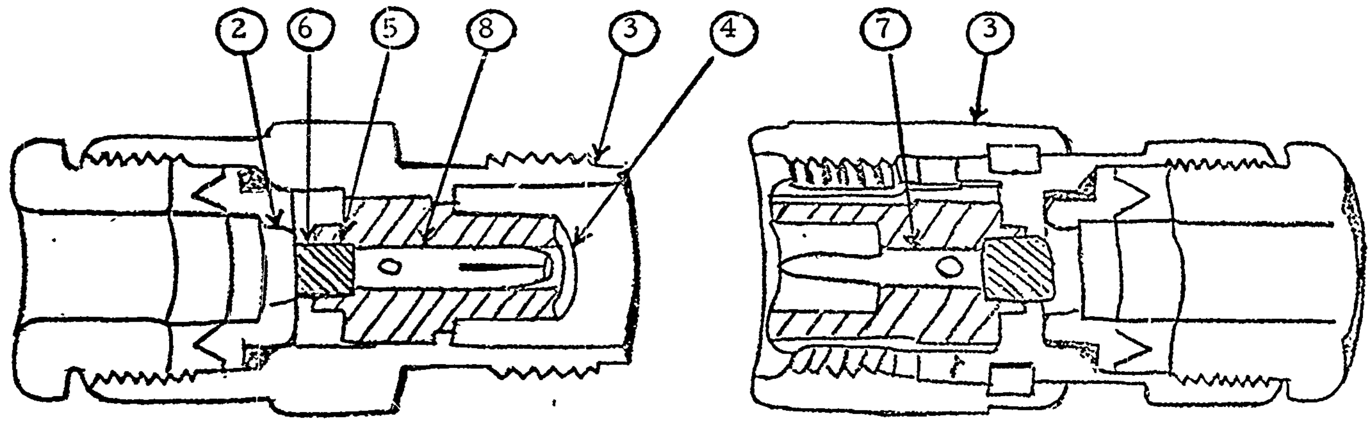

Figure 2 "TNC" Female and Male Connector and Configuration Change Areas as Recommended in Report

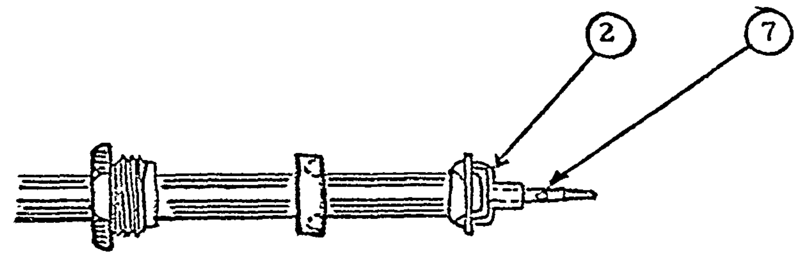

Figure 3 "TNC"Male Connector Pin and Configuration Change Areas as Recommended in Report

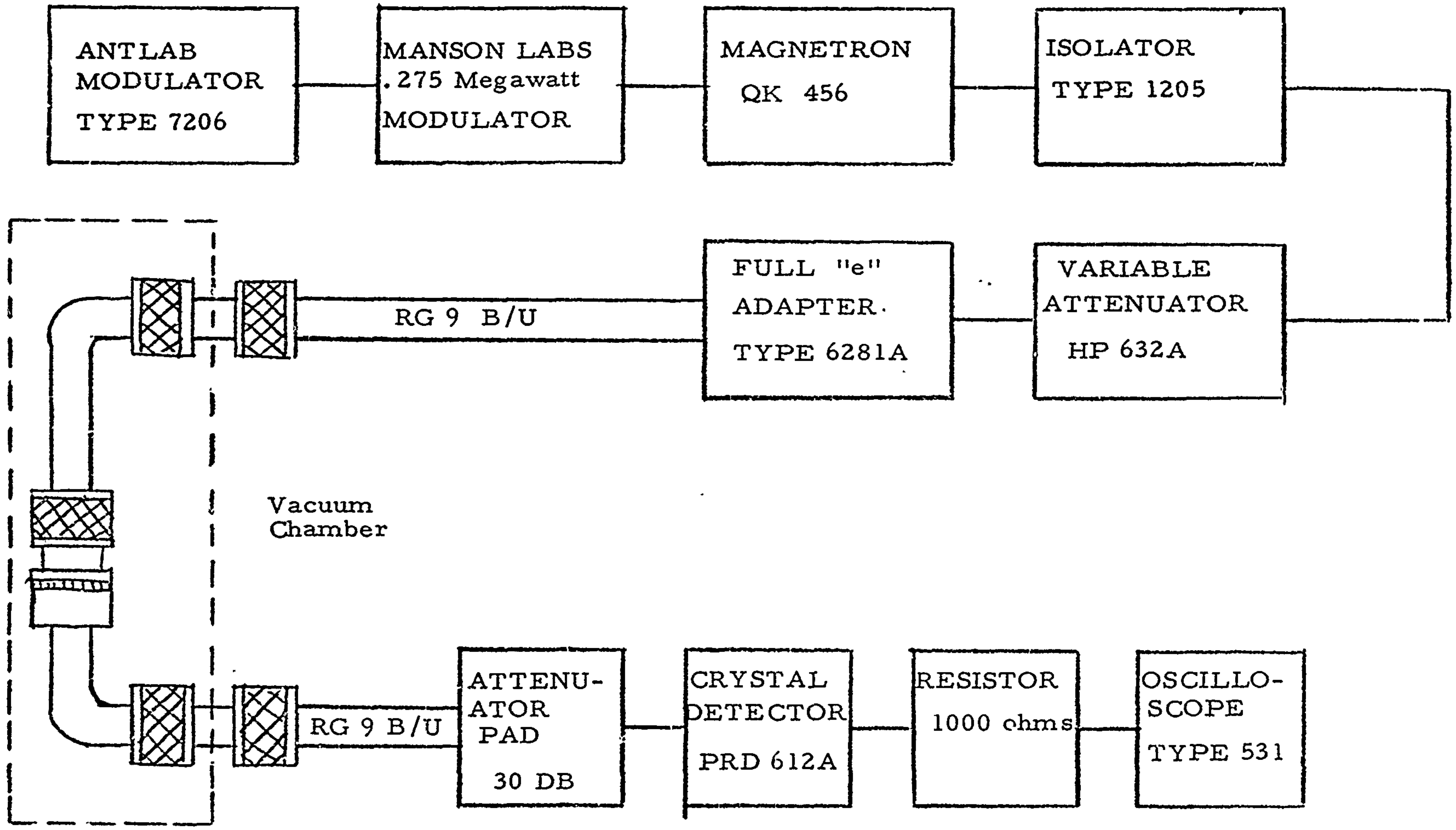

FIGURE 4 ELECTRICAL SET-UP FOR CONNECTOR BREAKDOWN TEST

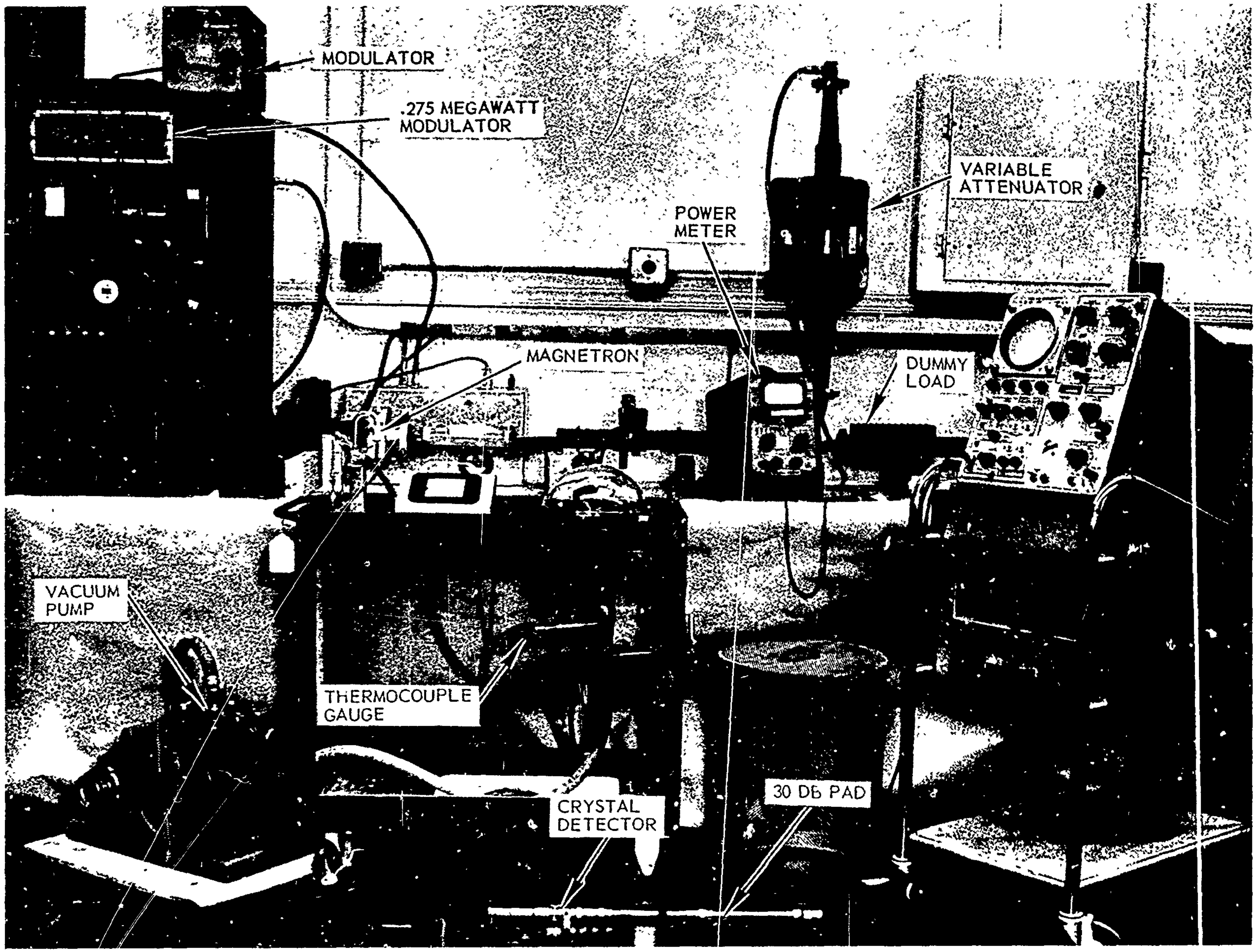

Figure 5. Electrical Test Set-Up

DO NOT MICROFILM

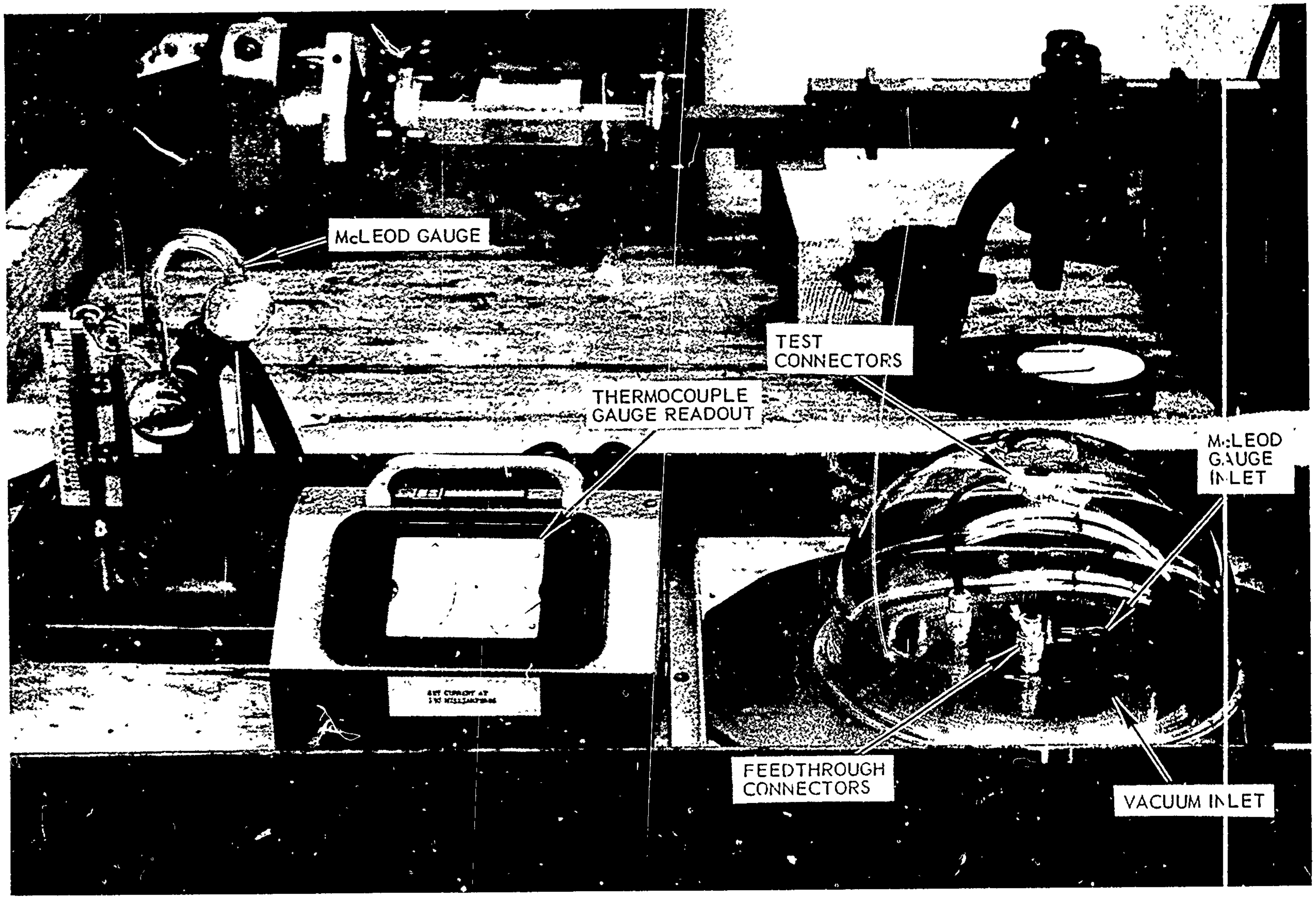

Figure 6. Vacuum Set-Up

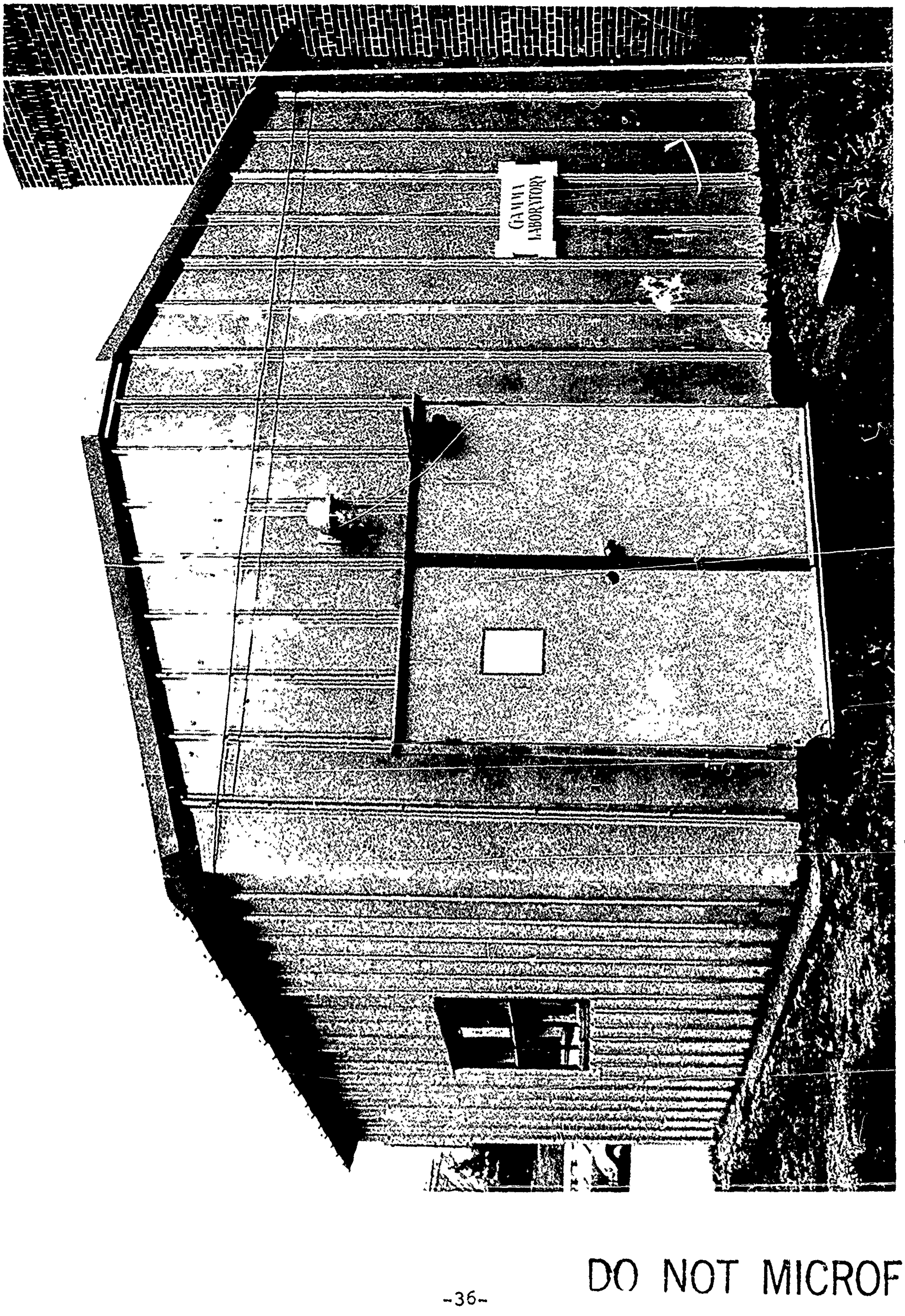

Figure 7. Gamma Laboratory

Figure 8. Cobalt 60 Control Panel and Drive Mechanism

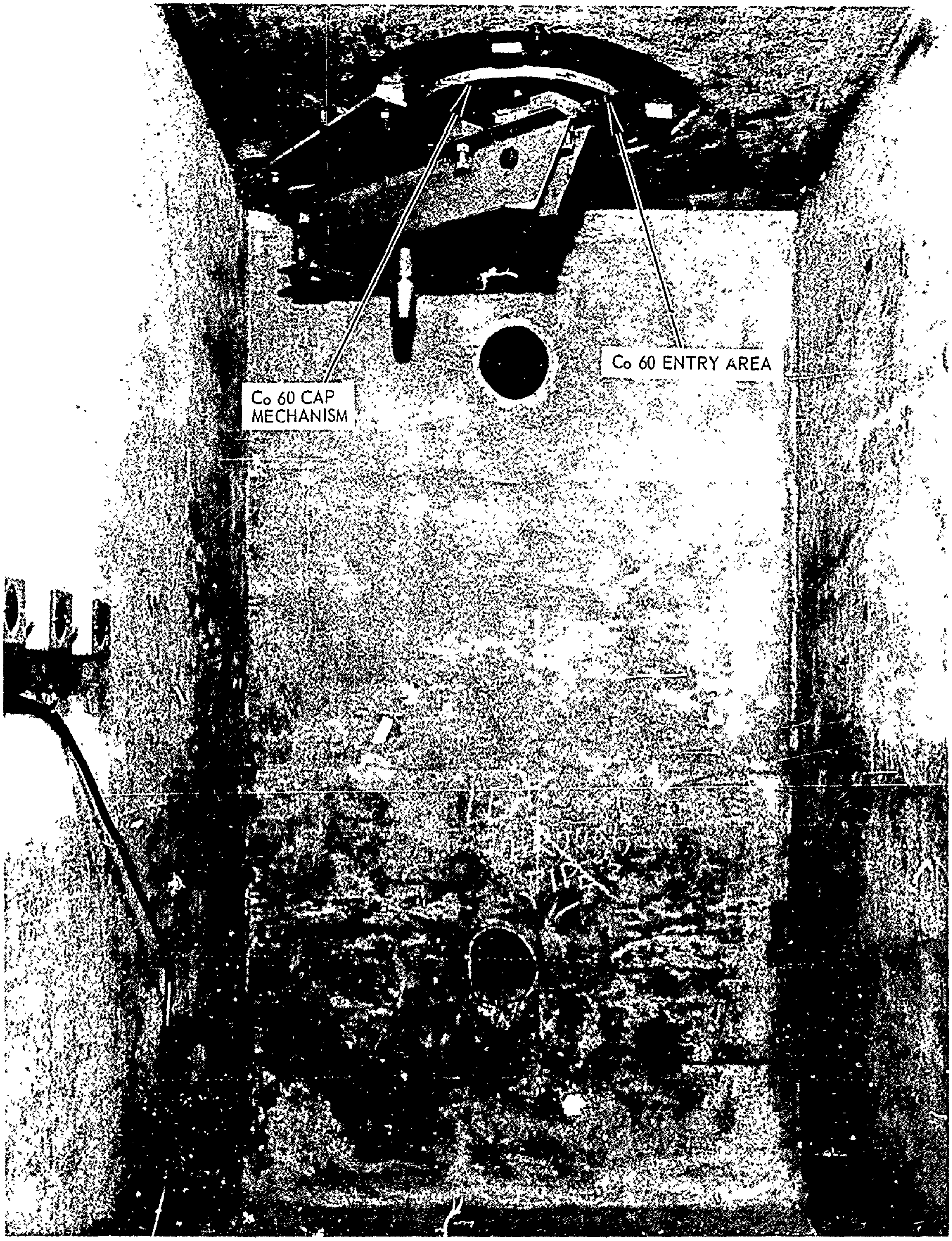

Figure 9. Gamma Laboratory Test Chamber, View 1

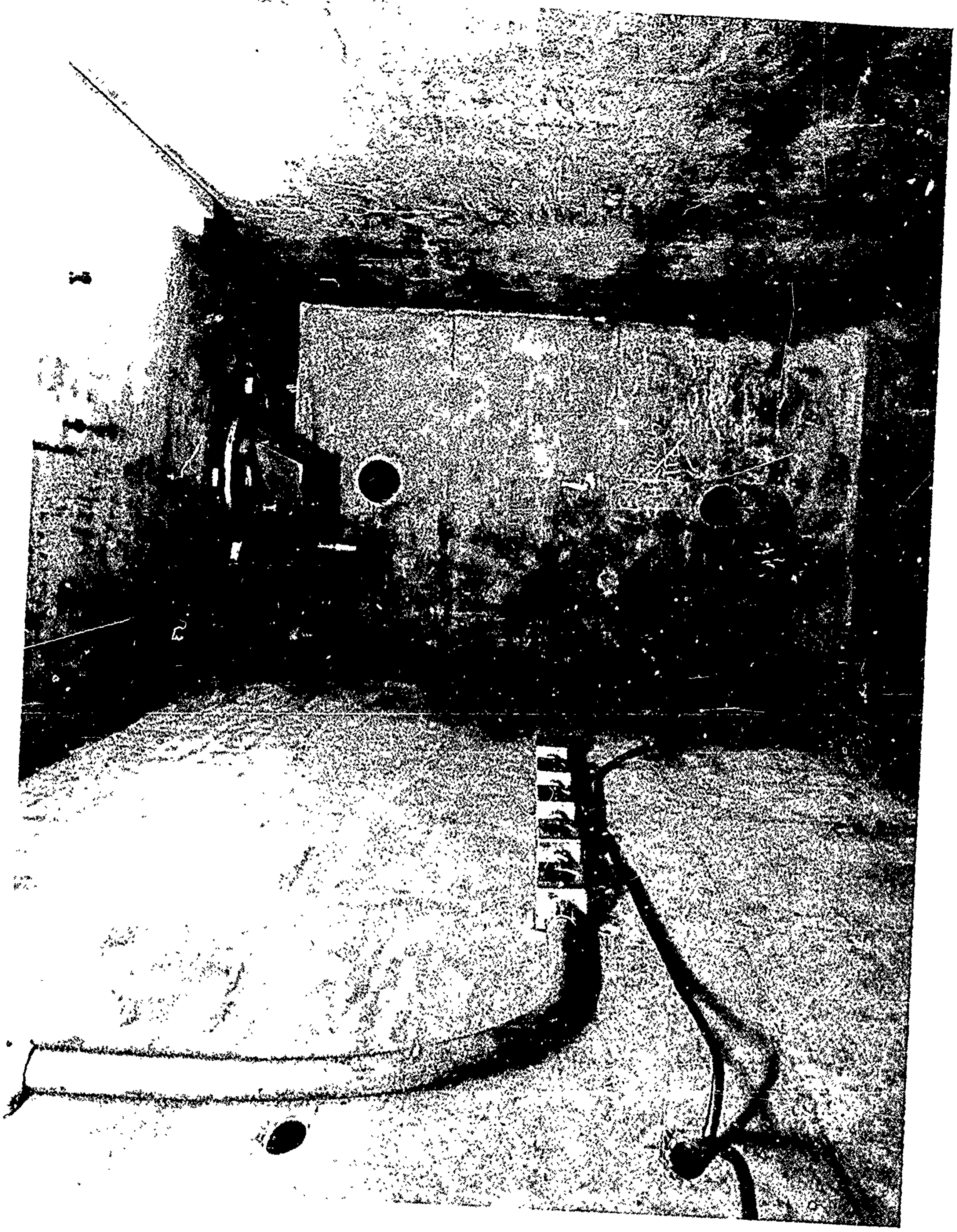

Figure 10. Gamma Laboratory Test Chamber, View 2

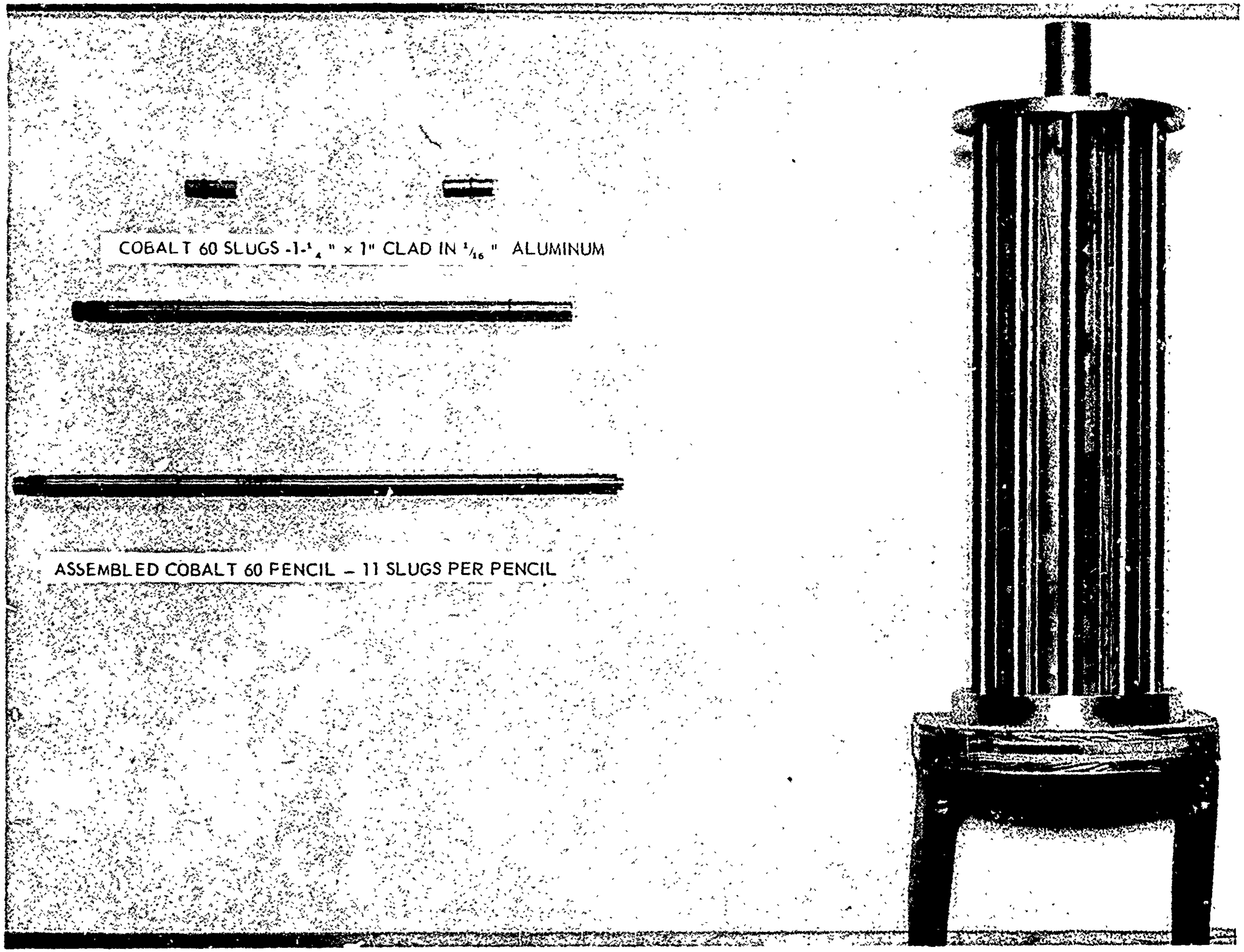

Figure 11. Cobalt 60 Source (Mock Up)

DO NOT MICROFILM

2.2 Corona Discharge Test

2.2.1 General

2.2.1.1 The initial tests were performed with a beacon antenna having a poorly plated surface on the exterior of the cavity. Several discontinuities were on the plated surface and the leading edge was very rough. The purpose of using a poorly plated surface was that if any corona discharge were to occur, it would occur at places on the plating where concentrations of abnormally high electric field existed.

2.2.2 Test Procedure

2.2.2.1 The beacon antenna, to be tested, was placed in a bell jar vacuum system and energized in the normal manner with 3000 watts (peak) R.F. power. The chamber pressure was then slowly reduced to 50 microns and then slowly returned to ambient atmospheric pressure. Any corona discharge occurring and the pressure at which it occurred was carefully noted.

2.2.3 Test Results

2.2.3.1 Corona glow appeared at a point on the circumference of the antenna window - the edge of the platinum plating. The roughness of the edge of the plating caused spots of high electric field strength initiating corona glow at approximately 600 microns. Maximum glow occurred at approximately 700 microns. The discharge glow had not quite extinguished at 50 microns. After returning to atmospheric pressure, the edge of the plating was smoothed with a conductive silver paint and the test repeated. No corona discharge appeared. The test was repeated on several antennas on which the plating was visually inspected, using a 5X magnification, for any indications of roughness and/or discontinuities. None were found. Under full power at increasing altitude, no corona discharge appeared.

2.3 Sinusoidal Vibration Test

2.3.1 General

2.3.1.1 During several portions of the Apollo flight, there exist times when vibrations containing sinusoidal components will occur. In order to test the ability of the antenna design to survive the force exerted by such vibrations the following test was performed.

2.3.2 Test Procedure

2.3.2.1 The test antenna was mounted in a vibration fixture designed to simulate the command module mounting position. Vibration was performed on the test sample across the frequency range of 5 to 2000 cycles per second. Across the band of 5 to 35 cycles per second, a constant displacement of 0.5 inches (peak to peak) was maintained. From 35 to 2000 cycles per second, a constant g level was maintained with the sweeps being repeated at 1, 5, 8, 10, 15, 20, and 30 g's (peak). The vibratory force was applied along one axis only - the most sensitive. That axis was the one perpendicular to the major axis of the quartz cylinder. Each vibration sweep across the range of 35 to 2000 cycles per second took from five to seven minutes.

2.3.3 Test Results

2.3.3.1 The antenna which was vibrated was not an electrical model and was not platinum plated, but in every other respect was representative of the design production model. At all frequencies and levels of vibration, no sign of mechanical degradation of the antenna occurred. The back cap mating bond withstood all of the testing with no signs of cracking of the bonding material or loosening of the required bond.

2.4 Combined Vibration and High Temperature Test

2.4.1 General

2.4.1.1 In the use environment, one of the sources of possible damage would be random vibration forces acting on the antenna in combination with elevated temperatures resulting from propulsion caused heating. Since there exists the possibility of the antenna materials degrading in structural strength as a result of such heating, damage could result from the application of forces which might have negligible effect at normal temperatures. The strength and resistance to damage of the antenna was therefore tested in the following tests.

2.4.2 Test Procedure

2.4.2.1 The antenna to be tested was mounted in a vibration fixture, designed to simulate the command module mounting. Random vibration was applied to the test antenna in the Y-axis, perpendicular to the longitudinal axis of the antenna. This is the most sensitive axis of the antenna. The random vibration was applied for 15 minutes with the following spectrum and shape:

10 to 100 cps --- linear increase from 0.01 g^2/cps to 0.7 g^2/cps

100 to 2000 cps -- constant at 0.7 g^2/cps

This represents an input of 37 G's (r.m.s.) across the 10 to 2000 cycle per second bandwidth.

2.4.2.2 During portions of this random vibration, heat was applied to the window of the beacon antenna. The heat input to the window was supplied by a 2 inch square, 96 jet, hydrogen fed torch. A low value of shear pressure was obtained by mounting the torch at a 45 degree angle to the longitudinal axis of the antenna. The effort to reduce any existing shear pressures was exerted in order to prevent any removal of quartz material as a result of mechanical forces other than vibration. Two heat input levels were applied to the test antenna; 9 Btu/ft.^{2} sec. and 29 Btu/ft.^{2} sec. The lower heat input was attained by burning the proper flow rate of hydrogen fuel with the surrounding atmospheric oxygen. The higher heat input was obtained by burning the hydrogen with oxygen from a compressed supply.

2.4.2.3 VSWR measurements were made before, during, and after each test run. Four vibration and high temperature runs were performed in the Y-axis.

Run 1. S/N #1 Type II Antenna

37 G's (r.m.s.) random vibration applied perpendicular to the longitudinal axis of the antenna for 15 minutes. Counting the start of vibration as time zero:

0- 85 seconds - vibration only

85-155 seconds - flame on sample - approximately 9 Btu/ft.^{2} sec.

155-170 seconds - vibration only

170-175 seconds - flame on sample - approximately 29 Btu/ft.^{2} sec.

Run #2. S/N #4 Type V Antenna

37 G's (r.m.s.) random vibration applied perpendicular to axis of the antenna for 15 minutes. Counting the start of vibration as time zero:

0- 55 seconds - vibration only

55-125 seconds - flame on sample - approximately 9 Btu/ft.^{2} sec.

125-150 seconds - vibration only

150-155 seconds - flame on sample - approximately

29 Btu/ft.^{2} sec.

150 seconds to 15 minutes - vibration only

Run #3. S/N #3 Type II Antenna

Same as Run #1.

Run #4. S/N #3 Type V Antenna

Same as Run #2.

2.4.3 Test Results

2.4.3.1 No electrical degradation or physical damage was sustained by any of the antennas during these tests.

TABLE 1. HEAT FLUX VARIATIONS

Gas	Flow ft.^{3}/min.	Distance from antenna, inches	Angle from antenna axis, degrees	Shear Pressure lb/ft.^{2}	Flux BTU/ft.^{2} sec.
Hydrogen	25	5	45	0.2	8.8
Hydrogen/air	25/12.5	5	45	2.9	29.2

Note

The temperature profiles as drawn on the figures are the result of the applied heat flux. Chromel-alumel couples were attached to the back of the antenna and to the flange and temperatures were recorded for the duration of the thermal test. In addition, the front surface temperature was monitored with a radiation pyrometer. The maximum front surface temperature indicated was 1380°F. at approximately two seconds after the hydrogen/air flame was removed.

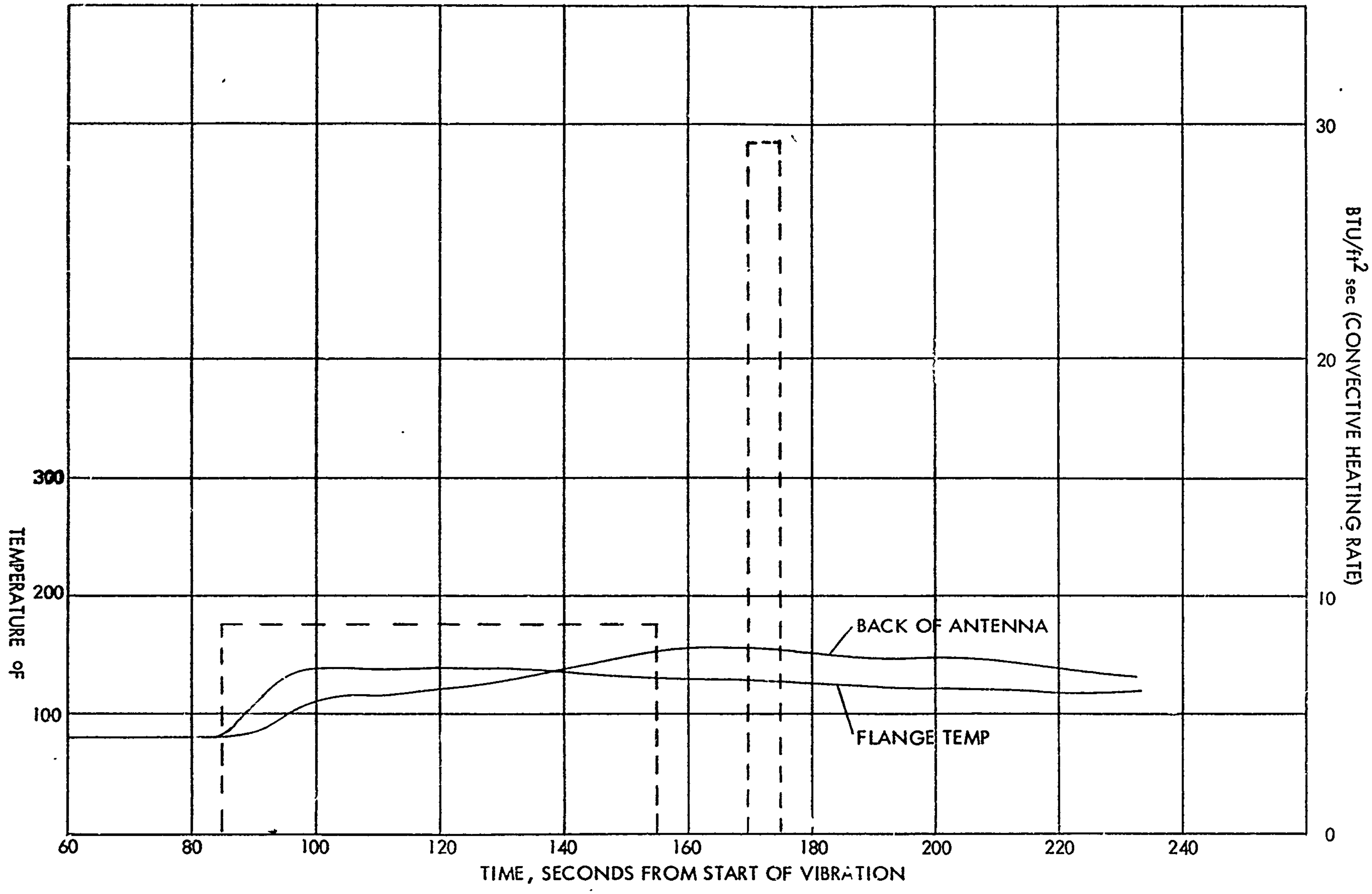

Figure 12. Combined Vibration and High Temperature Test No. 1

DATA SHEET #1 P-20013

NO: 6232A

APOLLO C BAND BEACON ANTENNA

Test Location: General Testing Labs. Moonachie, N. J. **Date:** 2-10-65

Test Personnel: Williams & Freedman **Signature:** I. Freedman

S/N: #1 Type II: Development Model **Signature:**

Freq. (mc)	1	2	3	4	5	6	7	8	9	10		
5640	1:34	1:21			1.20	1.21	1.22	1.20	1.20	1.36		
5725	1:40	1:24	1.26	1.25	1.25	1.24	1.24	1.24	1.24	1.44		
5815	1:58	1:22			1.22	1.22	1.21	1.24	1.23	1.56		
Time	10:30a	2:15p										

Notes:

All Readings are VSWR

1. Ambient Conditions - Antenna on Slotted Line
2. Ambient Conditions - Antenna in Holding Fixture
3. Vibration Only - No Flame - 37 G's (rms)
4. Vibration & High Temperature - 37 G's (RMS) - Flame Impinging upon Sample.
5. Vibration Only - No Flame - Immediately after Application of Flame
6. Vibration Only - 2 Minutes after Application of Flame
7. Vibration Only - 5 Minutes after Application of Flame
8. Vibration Only - 10 Minutes after Application of Flame
9. Ambient Conditions - Immediately after Vibration - in Fixture on Table
10. Ambient Conditions - Antenna on Slotted Line

* All vibrations at 37 g's (rms) perpendicular to axis of antenna.

* All VSWR readings taken with 53' of RG-142 (while on shaker table).

No physical damage to antenna (visible).

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Figure 13. Data Sheet No. 1

RE6303 (3-63)

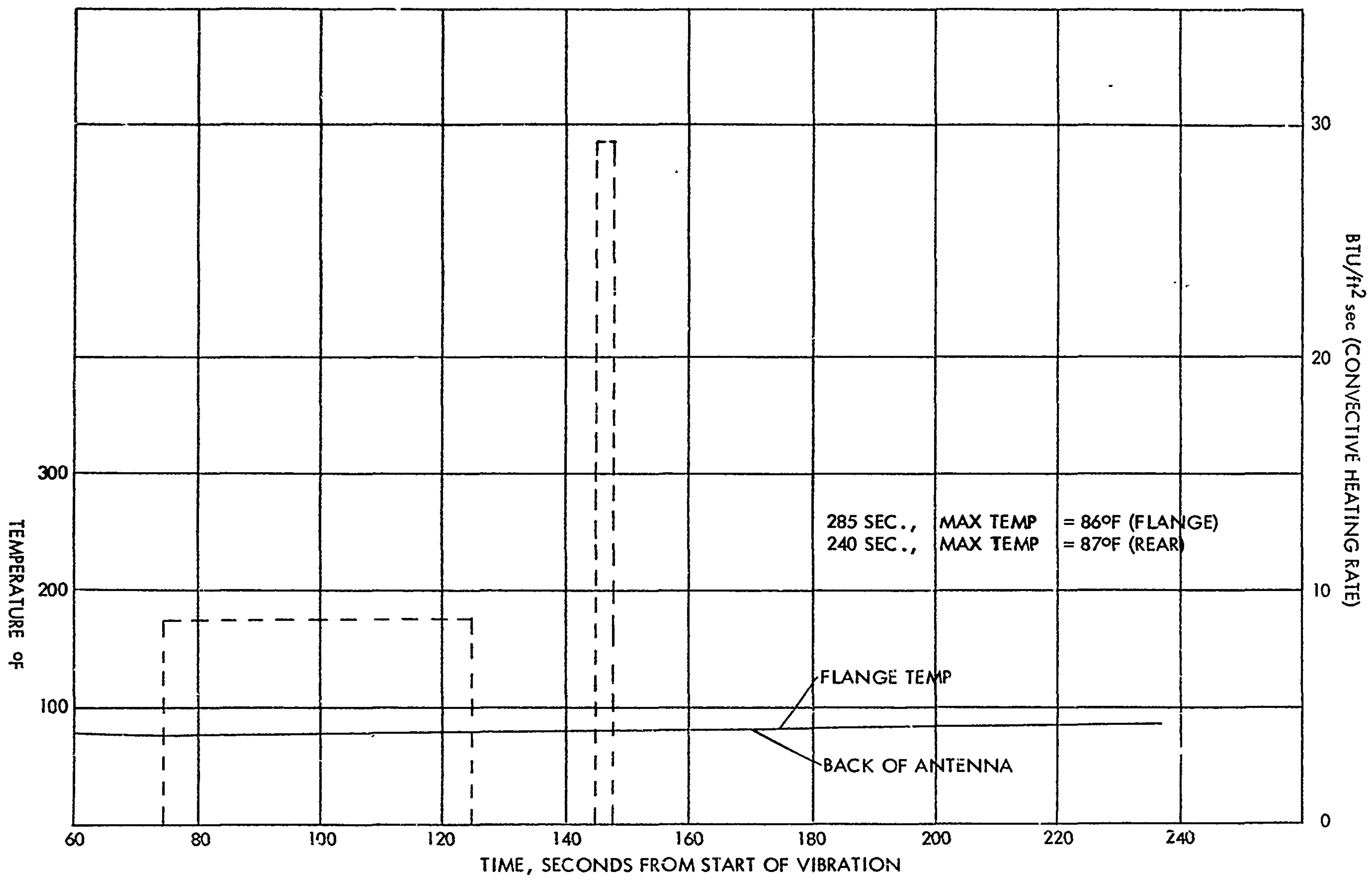

Figure 14. Combined Vibration and High Temperature Test No. 2

DATA SHEET #2 **P-20013**

NO: 6232A

APOLLO C BAND BEACON ANTENNA

Test Location: General Testing Labs. Moonachie, N. J. **Date:** 2-10-65

Test Personnel: Williams & Freedman **Signature:** I. Freedman

S/N: #4 Type V; Development Model **Signature:**

Freq. (mc)	1	2	3	4	5	6	7	8	9	10		
5640	1.62	1.28			1.28	1.27	1.27	1.28	1.29	1.64		
5725	1.18	1.32	1.28	1.30	1.29	1.29	1.28	1.29	1.30	1.20		
5815	1.30				1.30	1.30	1.30	1.28	1.30	1.25		
Time	4:15p		4:30p			5:33p	5:36p	5:38p	5:45p	6:11p		

Notes:

- All Readings are VSWR

1. Ambient Conditions - Antenna on slotted line
2. Ambient Conditions - Antenna in holding fixture
3. Vibration Only - No flame - 37 G's (rms)
4. Vibration & High Temperature - 37 G's (rms) - Flame impinging on test sample.
5. Vibration Only - No flame - Immediately after application of heat.
6. Vibration Only - No flame - 2 Minutes after application of heat.
7. Vibration Only - No flame - 5 Minutes after application of heat.
8. Vibration Only - No flame - 10 Minutes after application of heat.
9. Ambient Conditions - Immediately after vibration in fixture
10. Ambient Conditions - Antenna on slotted line

* All vibration at 37 G's (rms) perpendicular to axis of antenna.

* All VSWR readings in fixture taken with 53' of RG-142

No visible physical damage to antenna.

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Silver Spring, Maryland

SHEET 19A	SPEC. NO. 6232	REV.

Figure 15. Data Sheet No. 2

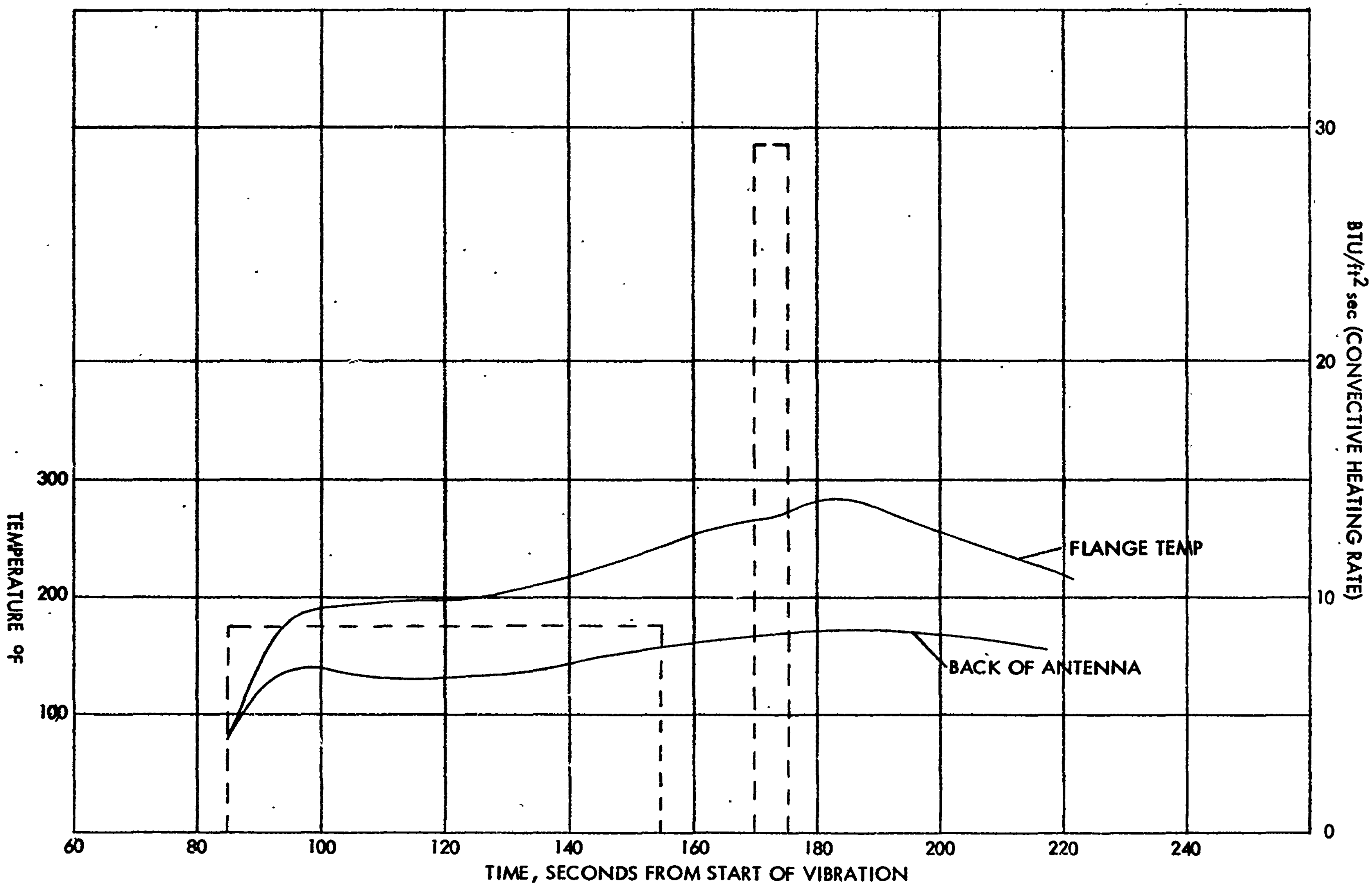

Figure 16. Combined Vibration and High Temperature Test No. 3

DATA SHEET #3 P-20013

NO: 6232A

APOLLO C BAND BEACON ANTENNA

Test Location: General Testing Labs. Moonachie, N. J. Date: 2-10-65

Test Personnel: Williams & Freedman Signature: I. Freedman

S/N: #3 Type II: Development Model Signature:

Freq. (mc)	1	2	3	4	5	6	7	8	9	10		
5640	1.56	1.27			1.26	1.26	1.25	1.26	1.25	1.55		
5725	1.47	1.32	1.29	1.31	1.29	1.31	1.30	1.32	1.30	1.45		
5815	1.44	1.22			1.22	1.23	1.22	1.22	1.23	1.40		
Time	6:50p	7:06p	7:18p	7:21p	7:22p	7:25p	7:26p	7:28p	7:32p	8:00p		

Notes:

- All Readings are VSWR

1. Ambient Conditions - Antenna on slotted line
2. Ambient Conditions - Antenna mounted in holding fixture on table.
3. Vibration Only - no flame - 37 G's (rms)
4. Vibration & High Temperature - 37 G's (rms) - Flame impinging on test sample.
5. Vibration Only - no flame - immediately after application of heat
6. Vibration Only - no flame - 2 Minutes after application of heat
7. Vibration Only - no flame - 5 Minutes after application of heat
8. Vibration Only - no flame - 10 Minutes after application of heat
9. Ambient Conditions - Immediately after vibration - in fixture on table
10. Ambient Conditions - Antenna on slotted line.

All vibration at 37G's (rms) perpendicular to axis of antenna

All VSWR readings on table taken with 53' of RG-42

No visible physical damage to antenna.

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SHEET 19A SPEC. NO. 6232 REV.

Figure 17. Data Sheet No. 3

NE6969 (9-63)

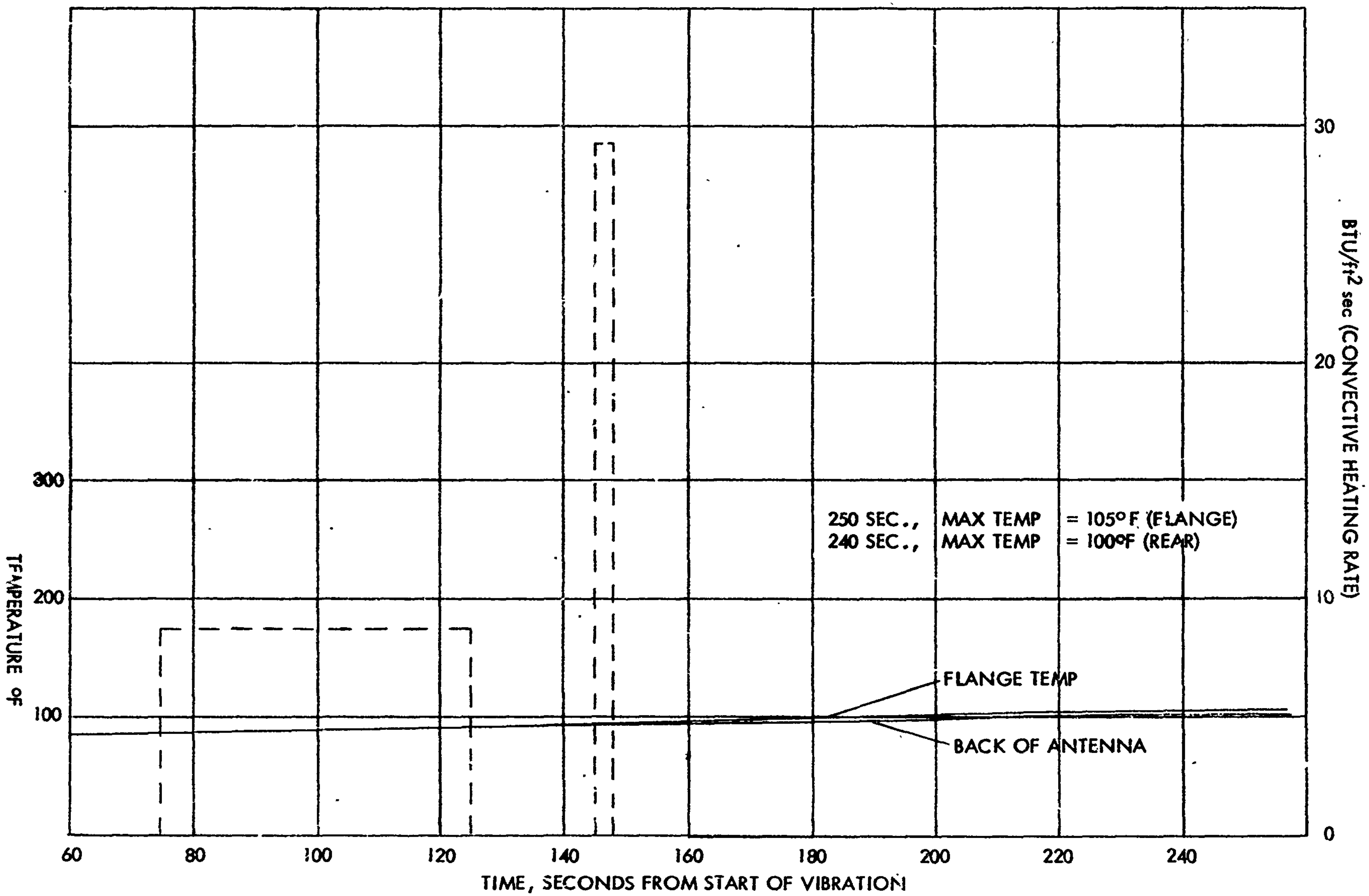

Figure 18. Combined Vibration and High Temperature Test No. 4

DATA SHEET #4 P-30013

NO: 6232A

APOLLO C BAND BEACON ANTENNA

General Testing Labs.

Test Location: Moonachie, N. J. **Date:** 2-10-65

Test Personnel: Williams & Freedman **Signature:** I. Freedman

S/N: #3 Type V: Development Model **Signature:**

Freq. (mc)	1	2	3	4	5	6	7	8	9	10		
5640	1.23	1.32			1.34	1.30	1.32	1.30	1.34	1.20		
5725	1.09	1.37	1.38	1.36	1.38	1.36	1.37	1.39	1.40	1.13		
5815	1.04	1.29			1.28	1.30	1.29	1.30	1.30	1.09		
Time	7:50p	8:07p	8:12p	8:13p	8:18p	8:17p	8:19p	8:22p		8:45p		

Notes:

- All Readings are VSWR

1. Ambient Conditions - antenna on slotted line.
2. Ambient Conditions - antenna mounted in holding fixture.
3. Vibration Only - No flame - 37 G's (rms)
4. Vibration & High Temperature - 37 G's (rms) - Flame impinging on test sample.
5. Vibration Only - No flame - immediately after application of heat.
6. Vibration Only - No flame - 2 minutes after application of heat.
7. Vibration Only - No flame - 5 minutes after application of heat.
8. Vibration Only - No flame - 10 minutes after application of heat.
9. Ambient Conditions - immediately after vibration - in fixture
10. Ambient Conditions - antenna on slotted line.

All vibration at 37 G's (rms) perpendicular to axis of antenna

All VSWR readings on table taken with 53' of RG-142

No visible physical damage to antenna.

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Silver Spring, Maryland

SHEET	SPEC. NO.	REV.
19A [illegible]	6232	

Figure 19. Data Sheet No. 4

RE6804 (8-63)

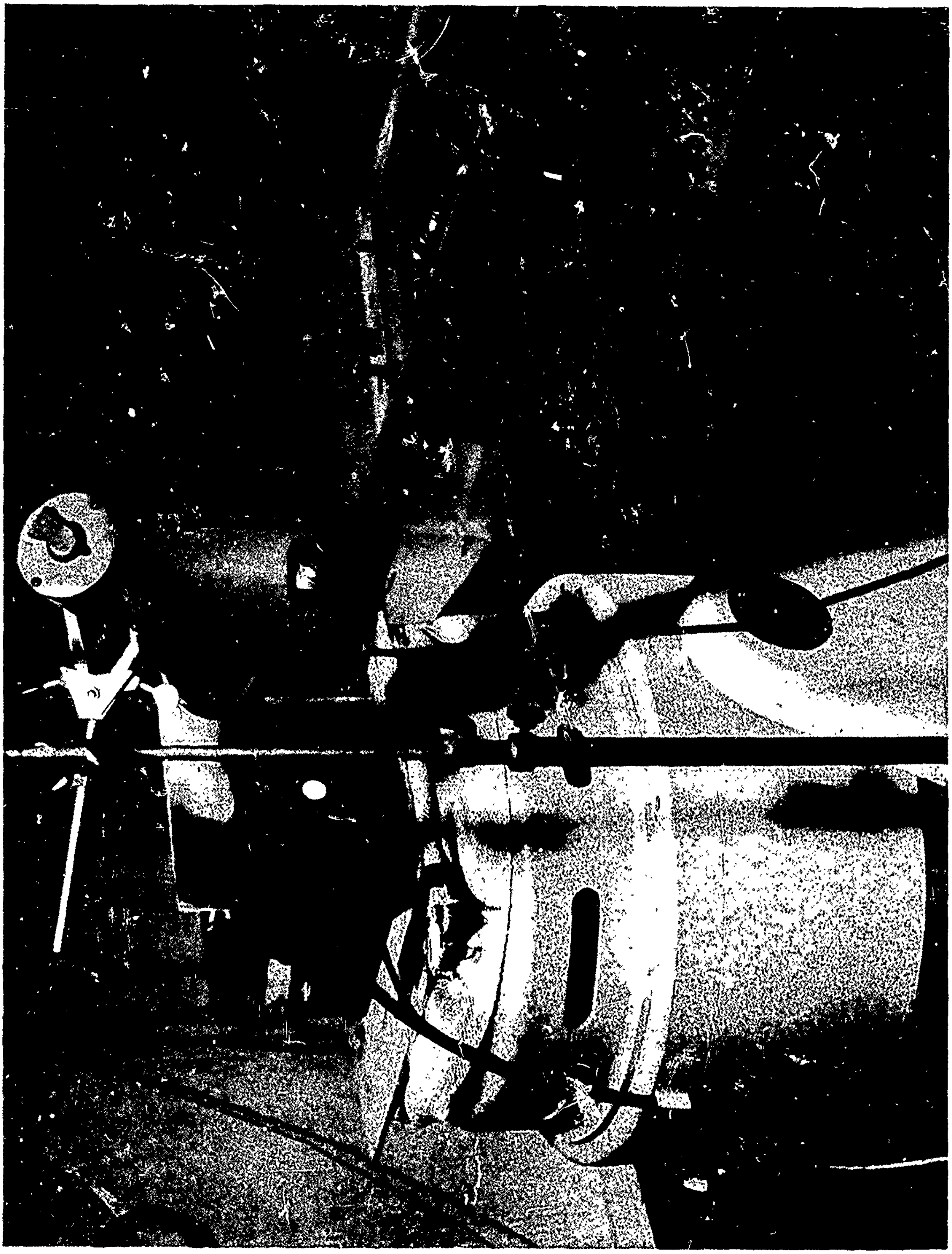

Figure 20. Combined Vibration and High Temperature Set-Up, View 1

DO NOT MICROFILM

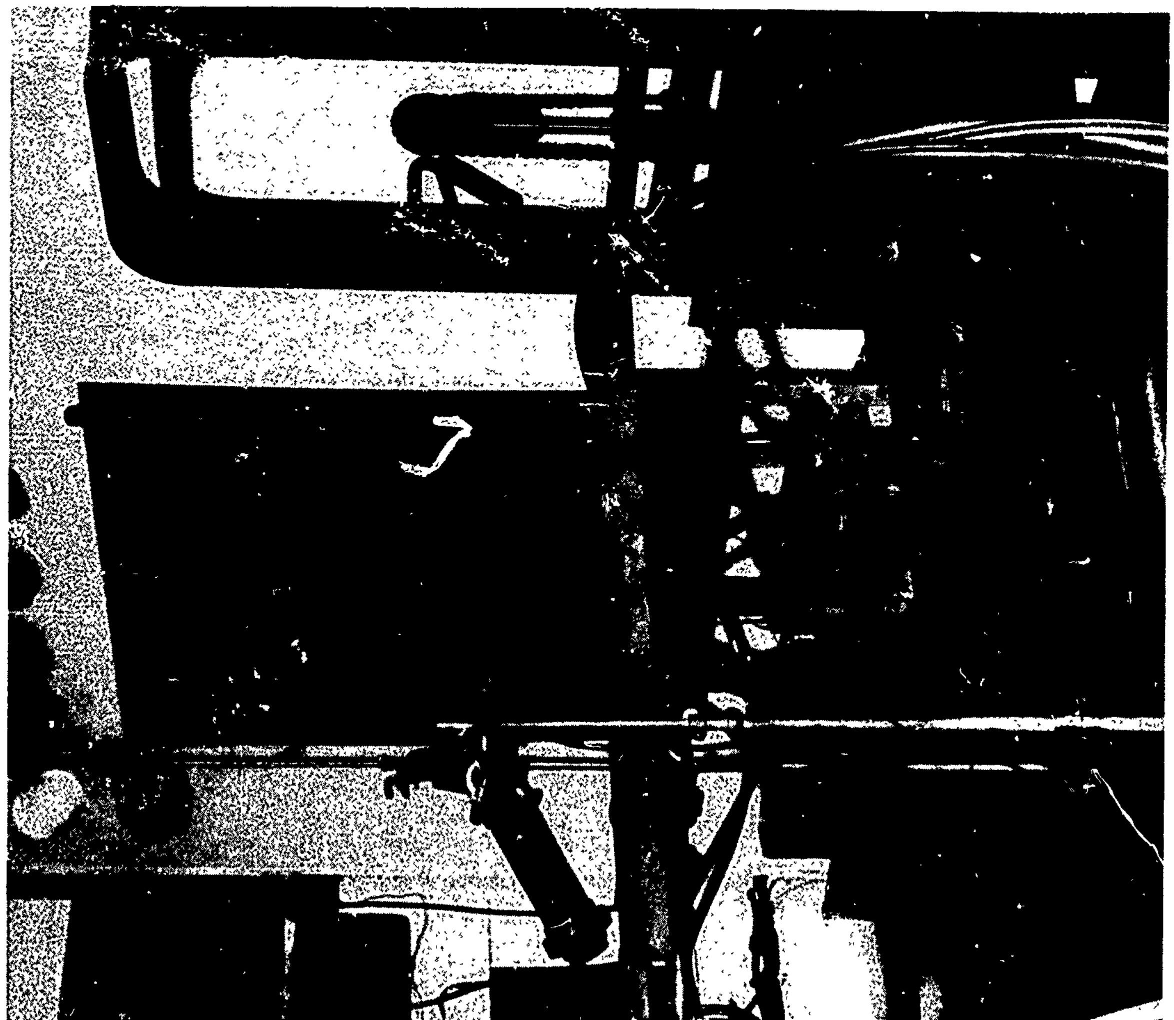

Figure 21. Combined Vibration and High Temperature Set-Up, View 2

2.5 Sand and Dust Test

2.5.1 General

2.5.1.1 Since the surface of the antenna window is intentionally sealed by a glaze coat to prevent any vapors or salts from entering the tuned cavity, a danger due to errosion of the glaze coat existed. The antenna could be exposed to a sand and/or dust laden atmosphere for an extended period of time. If, as the wind blew these abrasives across the surface of the antenna and caused the glaze coat to errode, large quantities of moisture vapor or atmospheric salts could be deposited within the body of the cylinder. These deposits would destroy the given electrical parameters of the antenna. Therefore, the following test was performed to determine if any errosion would occur under extreme conditions of sand and dust abrasives.

2.5.2 Test Procedure

2.5.2.1 The quartz rod to be tested was carefully glazed as outlined in Litton Procedure 6233. The cylinder was then checked for any absence of glaze coat using the leak test of Litton Procedure 6220. It was determined that a good glaze coat with no detectable leaks was on the rod. The unit was then subjected to the Sand and Dust Test specified in MIL-E-5272. The surface continuity was again checked using the helium leak test at the conclusion of the sand and dust exposure.

2.5.3 Test Results

2.5.3.1 No leaks were detected at the conclusion of the Sand and Dust test. The abrasive materials had not erroded the glaze coat surface.

2.6 Helium Leak Test

2.6.1 General

2.6.1.1 Since the possibility exists for the antenna to be exposed to a salt atmosphere for an extended period of time, it is important that the antenna window exclude moisture and atmospheric salts from the interior pores. This type of absorption could result in a degradation of electrical properties.

2.6.1.2 The manner in which the quartz rods are manufactured produces a material that is extremely porous, permitting the migration of gases and vapors from the outside surface to the rods interior. To prevent this from happening, the quartz cylinder is glazed, using a special Litton high temperature process. This glazing process seals the rod with a thin non-porous surface. To prevent a failure from occurring as a result of an inadequate glaze coat, the following technique was developed and tested in order to investigate the continuity of the surface glaze.

2.6.2 Test Procedure

2.6.2.1 The quartz sample to be tested was placed in the set-up as shown in Figure 22. The bottom seal was constructed of silicon rubber in such a manner that its height did not pass the retaining groove machined into the quartz rod. This was done in order to permit all surface area which would be exposed in normal antenna construction to be tested. The surface area below the groove would normally be sealed by the back cap bonding material; therefore, leakage in this area was not of concern.

2.6.2.2 After the quartz rod was properly seated in the bottom seal, a vacuum was drawn within the quartz rod. Pumping action was sustained throughout the test. After the vacuum reading was stabilized, the exterior of the quartz rod was sprayed with helium. If any leak should exist in the glazed surface, the helium would be drawn through the break in the surface glaze into the porous interior of the quartz rod. From here, the helium would be forced into the vacuum system and to the mass spectrometer. As a result, the current across the mass spectrometer tube would increase and be evidenced on the indicating current meter.

2.6.2.3 Three cylinders were investigated:

(1) an unglazed unit

(2) an obviously poorly glazed unit

(3) an apparently well glazed unit

2.6.2.4 After the initial test, each unit was plated with a platinum coating as per Litton Procedure 6234. At this time, the test was repeated on each of the three now plated samples.

2.6.3 Test Results

2.6.3.1 With the unglazed unit in place in the test set-up, insufficient vacuum was obtained to make use of the diffusion pump or to utilize the mass spectrometer. This was an evident indication of the massive leakage which occurs through the pores of a quartz rod having no glaze seal coat. Though not the point of the test, the need for some sort of sealing process was certainly and obviously indicated by this rapid transmission of gas and vapor through the rod.

2.6.3.2 With the second unit, the poorly glazed unit, in place; a sufficient vacuum was obtained to utilize the mass spectrometer. When helium was sprayed upon the surface of this unit, there was an immediate indication of a large passage of helium through the sample. With the third test sample, one apparently well glazed, in the test set-up, a sufficient vacuum was rapidly acquired. When helium was sprayed upon its surface, no indication of any leak was produced on the meter.

2.6.3.3 When the test was repeated with the plated units, the first unit (unglazed) still passed enough gas and vapor to prevent the use of the diffusion pump and mass spectrometer. The second unit (poorly glazed) was sufficiently sealed so that no leaks could be detected by the leak detector. The third unit remained impervious to the passage of gas.

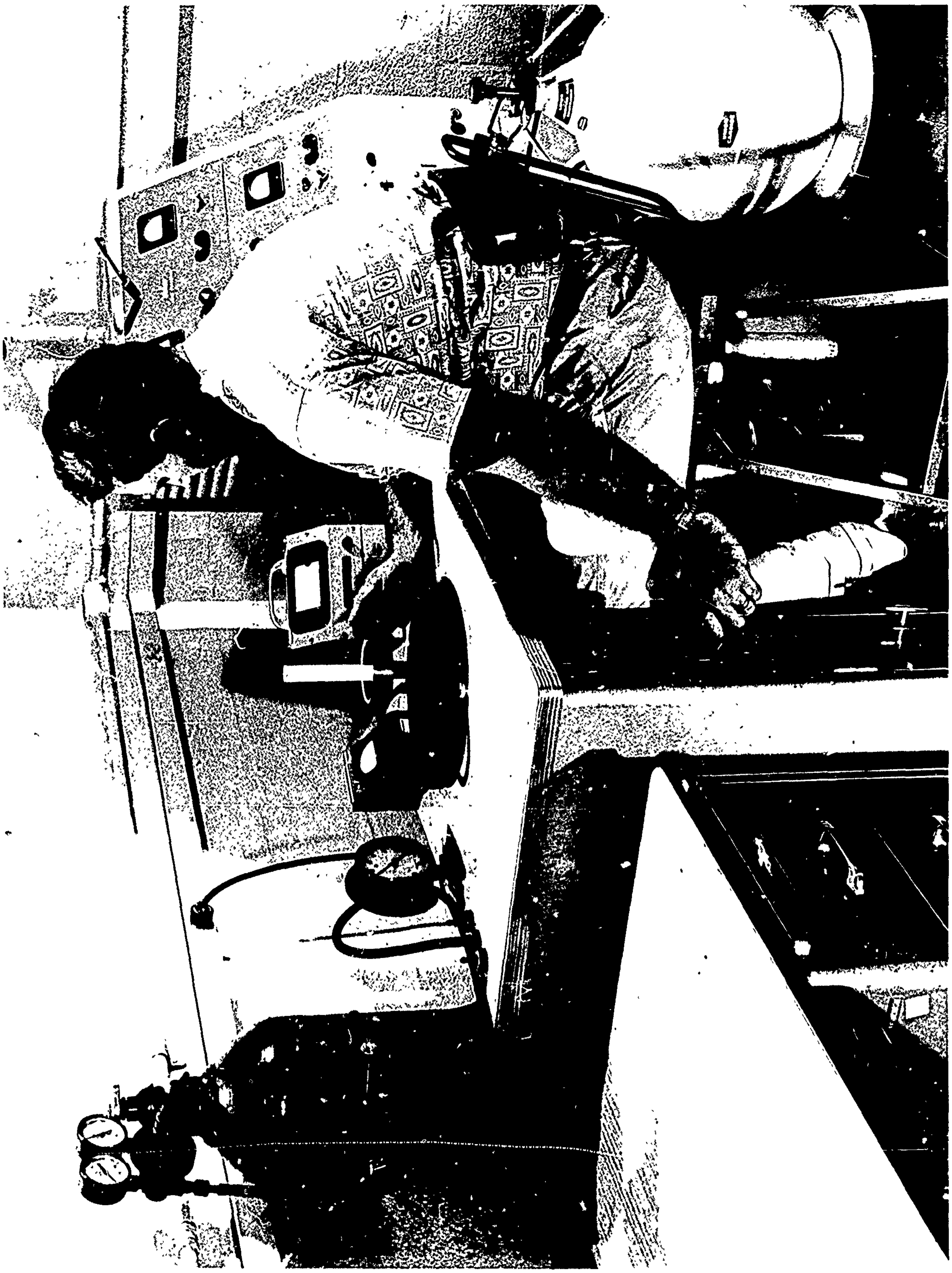

Figure 22. Helium Leak Testing

2.7 Off-Limits Vibration Test

2.7.1 General

2.7.1.1 In an effort to determine the level at which an antenna failure could occur, excessive levels of random vibration were applied to the antenna.

2.7.2 Test Procedure

2.7.2.1 The antenna to be tested was mounted in a vibration fixture designed to simulate the command module mounting configuration. This fixture had an acceleration gain of less than 1.5:1 across the frequency band of 5 to 2000 cycles per second. The fixture was mounted atop an electrodynamic vibration exciter. Random vibration across a frequency range of 5 to 2000 cycles per second was applied perpendicular to the longitudinal axis of the antenna. The vibration was maintained at five levels for a period of five minutes per level.

Level No. 1 ......37G's (RMS)

Level No. 2 ......46.5G's (RMS)

Level No. 3 ......55.5G's (RMS)

Level No. 4 ......74G's (RMS)

2.7.2.2 The VSWR of the antenna was measured before and after the test. The VSWR was monitored at intervals during the test.

2.7.3 Test Results

2.7.3.1 No significant changes in antenna VSWR occurred during this test. At the 74 G level the Lefkoweld seal cracked around the periphery of the back cap.

DATA SHEET #9 **P-20013**

NO: 6232A
APOLLO C BAND BEACON ANTENNA

Test Location: General Testing Labs. Moonachie, N. J. **Date:** 2-11-65
Test Personnel: Williams & Freedman **Signature:** I. Freedman
S/N: #4 Type V: Development Model **Signature:**

			Level I	II	III	IV	V					
Freq. (mc)	1	2	3	4	5	6	7	8				
5640	1.65	1.23	1.20	1.21	1.23	1.22	1.22	1.85				
5725	1.26	1.22	1.22	1.23	1.23	1.22	1.23	1.17				
5815	1.42	1.16	1.18	1.19	1.18	1.18	1.18	1.42				
Time	11:21a	11:30a	11:39a	11:46a	11:53a	12:00a	12:20a	12:30a				

Notes:

All Readings are VSWR

1. Ambient Conditions - Antenna on slotted line.
2. Ambient Conditions - Antenna in holding fixture.
3. Vibration Only - 37 G's (rms) Level I
4. Vibration Only - 46.5 G's (rms) Level II
5. Vibration Only - 55.5 G's (rms) Level III
6. Vibration Only - 65 G's (rms) Level IV
7. Vibration Only - 74 G's (rms) Level V - Lefkoweld Seal Cracked
8. Ambient Conditions - Antenna on slotted line.

The lefkoweld seal cracked at 74 G level.

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Figure 23. Data Sheet of Off-Limits Vibration Test

2.8 Acoustic Test

2.8.1 General

2.8.1.1 Not all vibratory forces to which the beacon antenna will be subjected are of a structure borne nature. Some will be transmitted as acoustic blasts having a random frequency and amplitude distribution. To determine the antenna's ability to withstand these forces the following tests were performed.

2.8.2 Test Procedure

2.8.2.1 This test was performed on two antennas; a Type II and a Type V. Each antenna was suspended, by flexible cords, within the test chamber. The VSWR of each antenna was measured with the antenna mounted directly on the slotted line, before and after each acoustic blast. Three runs were performed. On the first, the antenna was within the acoustic energy field five minutes. On the second, the antenna was within the field for fifteen minutes. On the third run, the antenna was within the acoustic field for thirty minutes. This procedure was decided upon as a means of overtesting the antenna. At the time these tests were conducted it was impossible to obtain an acoustic field with a total energy spectrum of over 159 db having the required energy-frequency distribution. To overtest the antenna by increasing the field strength was not possible. The overtesting, therefore, was accomplished by extending the time period of application.

2.8.2.2 The frequency and levels of acoustic testing were as follows:

Frequency (cps)	Levels (db)
22.5 - 45	136
45 - 90	142
90 - 180	152
180 - 355	152
355 - 710	150
710 - 1,400	144
1,400 - 2,800	143
2,800 - 5,600	142
5,600 - 11,200	140
11,200 - 22,400	137
22,400 - 40,000	132
Overall	159

2.8.3 Test Procedure - Acoustic Developmental Test No. 2

2.8.3.1 Acoustic testing of 1 long and 1 short Apollo C-Band Beacon Antenna was performed at the Sonic Test Facility of the Los Angeles Division of North American Aviation, Inc.

2.8.3.2 The intensity of the noise field impinging upon the face of the antenna window was 170 db with a spectrum shape as follows:

Frequency (cps)	Level (db)
37.5 to 75	158
75 to 150	160
150 to 300	155
300 to 600	152
600 to 1200	149
1200 to 2400	150
2400 to 4800	151
4800 to 9600	152
Overall	170

2.8.3.3 The antennas were mounted in a test fixture designed to simulate the command module mounting locations (See Litton drawing No. SK3672).

2.8.3.4 It was desired during this development test to over stress the antenna. The intensity level could not be increased because of another test specimen located in the reverberation chamber. Therefore, overstressing of the test sample was accomplished by extending the test time from 5 to 15 minutes.

2.8.3.5 The test antennas were located in a 2' x 4' x 5' progressive wave section which is part of the throat of the facilities' catenoidal horn. The test fixture was mounted with the outside face of the ablative cover projecting into the throat of the horn. The window of the test antenna was flush with the surface of the ablator.

2.8.3.6 Prior to the test, the VSWR and Axial Ratio of both antennas were measured at both band ends and at the center of the band. High power was also applied to determine whether or not internal arcing would occur. During the sonic tests the reflection coefficient of the antennas was monitored in order to determine what variations would occur. After testing the complete pretest measurements were repeated.

2.8.4 Test Results

2.8.4.1 During the test runs the antenna reflection coefficient was monitored as shown in Figure 28. No variations greater than 10 percent were observed. No mechanical degradation of the antennas occurred. No internal arcing occurred to either antenna before or after acoustic testing. See Figure 29 for Test Measurement Data.

DATA SHEET #11 P-20013

NO: 6232A
APOLLO C BAND BEACON ANTENNA

Test Location: Aerotest Lab Date: 2-15-65
Test Personnel: Williams& Freedman Signature: I. Freedman
S/N: #3 Type V Signature: A. Williams

Freq. (mc)	1	2	3	4								
5640	1.30	1.30	1.30	1.28								
5725	1.20	1.16	1.20	1.25								
5815	1.24	1.18	1.21	1.16								
Time	1115	1322	1350	1430								

Notes:

1. Antenna on slotted line ambient temperature
2. Antenna on slotted line after 5 minutes in chamber.
3. Antenna on slotted line after 15 minutes in chamber.
4. Antenna on slotted line after 30 minutes in chamber.

All measurements are VSWR

All testing was done at ambient temperature

American Information and Control Division
LITTON SYSTEMS, Inc.
Silver Spring, Maryland

SHEET 19A SPEC. NO. 6232 REV.

RE0000 (8-63)

Figure 24. Data Sheet of Acoustic Test

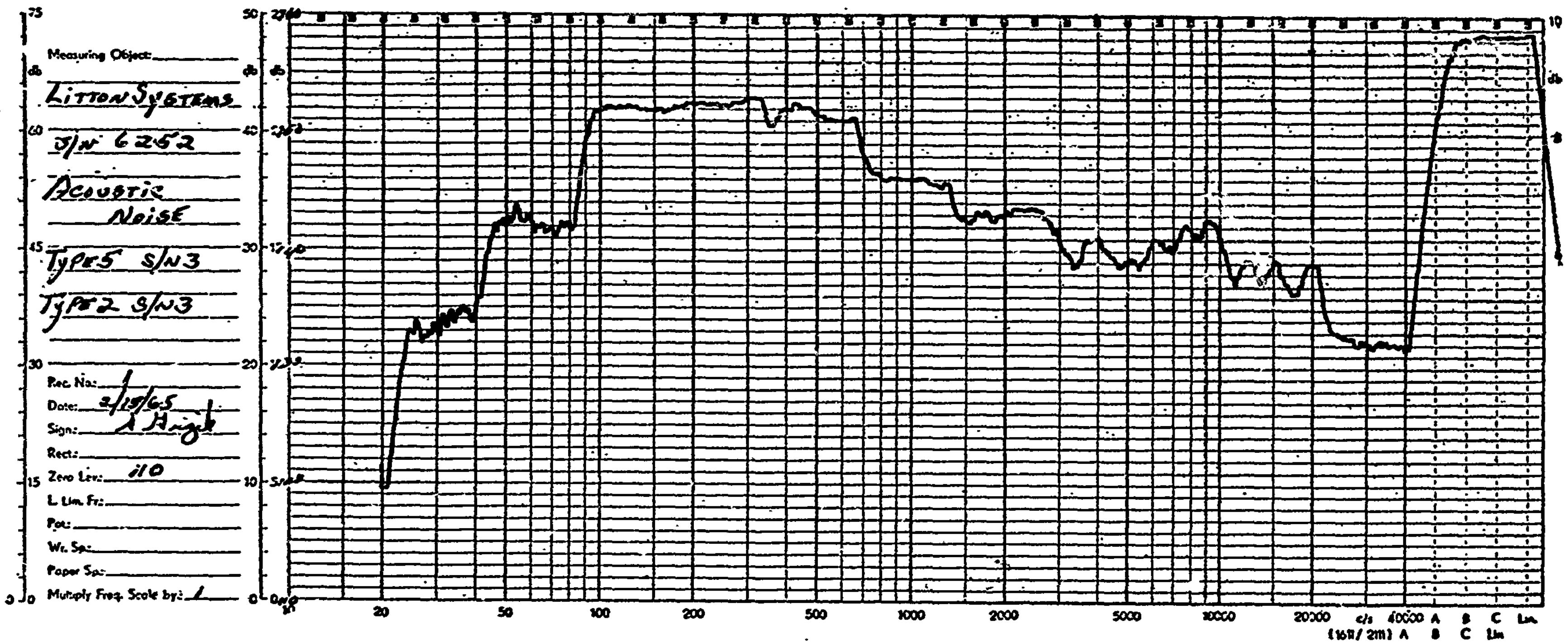

Figure 25. Reproduction of Acoustic Test Graph

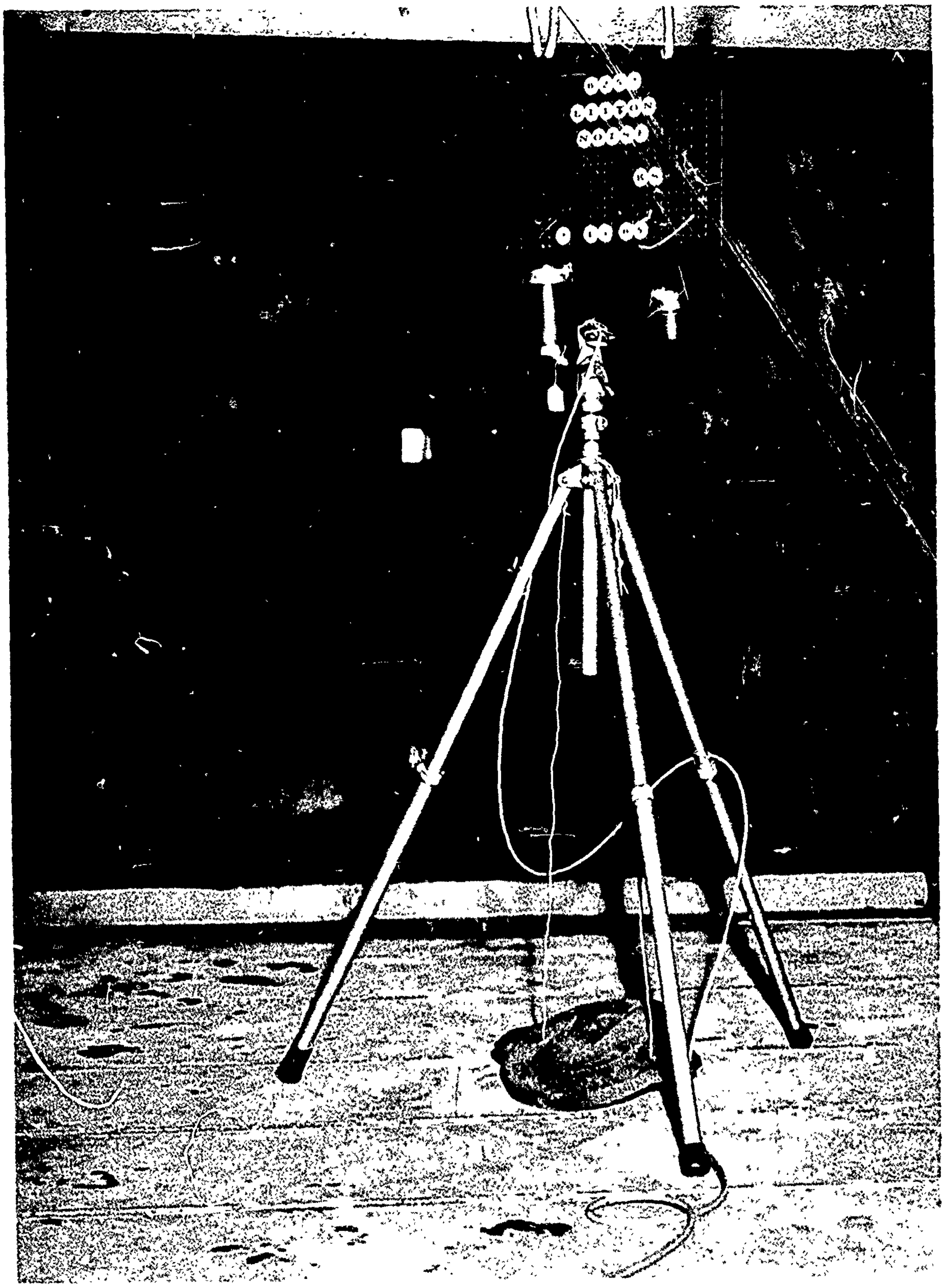

Figure 26. Set-Up for Acoustic Testing

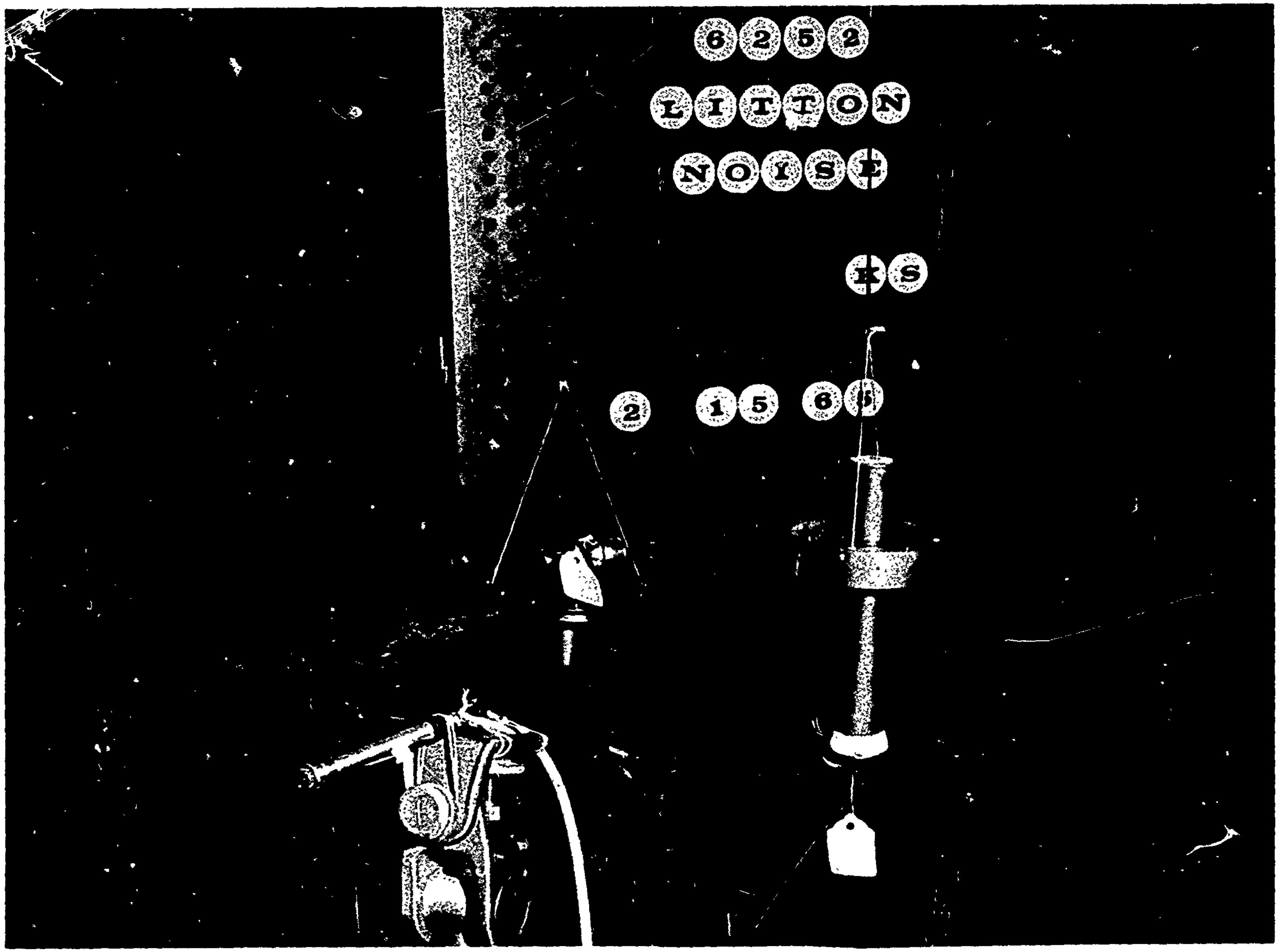

Figure 27. Close-Up View of Acoustic Testing

DO NOT MICROFILM

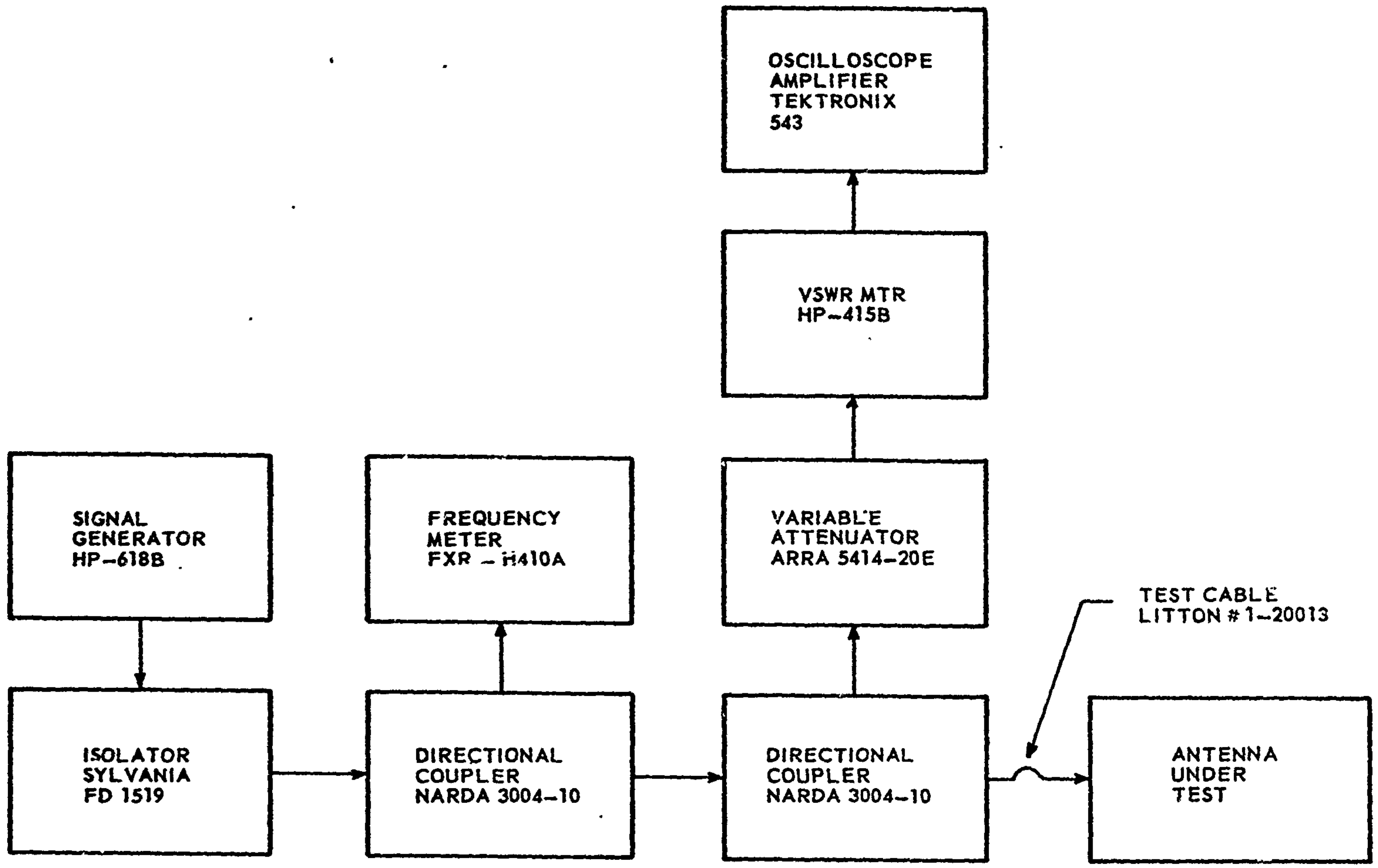

Figure 28. Equipment Set-Up - VSWR Measurement During Acoustic Test

	Frequency(mc)	Pre-test VSWR	Post-test VSWR	Pre-test A/R	Post-test A/R
Short Antenna					
	5640	1.35:1	1.16:1	1.9 db	1.1 db
	5727	1.39:1	1.24:1	1.0 db	0.8 db
	5815	1.55:1	1.65:1	1.0 db	1.1 db
Long Antenna					
	5640	1.22:1	1.45:1	2.1 db	1.6 db
	5727	1.24:1	1.48:1	1.5 db	0.6 db
	5815	1.80:1	1.65:1	1.0 db	0.8 db

Figure 29. Pre-test and Post-test Measurements

2.9 Antenna to Back Cap Bond Test

2.9.1 General

2.9.1.1 As a result of cracking which occurred in the Lefkoweld bonding material during developmental high-low temperature testing, a series of each cap bonding materials and designs were tested.

2.9.2 Test Procedure

2.9.2.1 Since the cracking of the Lefkoweld bonding agent occurred during vibration and high-low temperature testing, both of these environments were suspected causes. However, samples subsequently vibrated, at room ambient temperature, at much higher G levels showed no signs of cracking; indicating that temperature not vibration was the problem. Not all samples that were tested creacked under vibration and temperature testing, indicating that design improvements were needed on a basically good design.

2.9.2.2 During the early part of this testing, the original design and materials were tested at both plus 250°F and minus 150°F. None of the samples cracked at the high temperature, and most did crack at the low. This raised the possibility that the nature of the Lefkoweld was such as to form cracks at this low temperature. To test this hypothesis, Lefkoweld strips were formed and cured on silicon grease coated metal plates. The grease was to keep the Lefkoweld from bonding to the metal plates and cracking due to differential contraction. None of these strips cracked when tested at minus 150°F.

2.9.2.3 The question of excessive contraction of the bonding agent relative to the slight contraction of the quartz window body was raised. To test this idea a bead of bonding material was formed around the quartz window. The temperature of this sample was then reduced to minus 150°F. The bead cracked.

2.9.2.4 The next step was to test several styles of back caps. Some had slots cut through the gripping surface, some had T-notches, some were thin walled and some had the original wall thickness. These various stainless steel back caps were fixed to the quartz bodies with one of three bonding agents:

1. Poly Sulphide Epoxy T120-3
2. Silver Epoxy - Epoxy Products #3022
3. Locktite Grade A

2.9.2.5 Two back caps were even tested with no bonding agents securing them. And two tests were run using a ring of T120-3 epoxy and no back cap. These various configurations were tested in the following manner. A particular design and bonding agent were joined to form a unit. The bonding process was accelerated by curing at an elevated temperature. After curing and cooling, the unit was subjected to a temperature variation between plus 250°F and minus 150°F. All temperature transitions were gradual so as to constitute <u>no</u> thermal shock. Those units that did crack, consistently did so at the low temperature. These tests indicated that the cracking was being caused by the difference in the amount of contraction among the three materials - back cap, bonding agent, and quartz.

2.9.2.6 It was decided to place an extreme stress on those units which survived the above test intact. These units were plunged into a rapidly boiling liquid nitrogen bath. The boiling was occurring at room ambient pressure. This represents a rapid temperature depression to approximately minus 320°F. In all but two of the remaining units either the bonding agent cracked or the quartz broke. With no external pressure applied, the quartz is capable of sustaining this extreme thermal shock with no injurious results. The consistent damaging of the quartz in this test gave further evidence to the real problem being differential contracting leading to incompatibility of the quartz and stainless steel back cap during conditions of temperature depression. What was needed was a back cap material having a coefficient of thermal expansion closer to the low coefficient of the quartz. An investigation of possible conducting materials lead to the choice of "Kovar", an iron, nickel, cobalt alloy having a very low contraction rate with temperature decrease. Three sample back caps were made using Kovar. These were bonded to the quartz body using a glueline filler of bonding agent. One each was joined with:

1. T120-3 Poly Sulphide Epoxy
2. 3022-Silver Epoxy
3. Locktite Grade A

2.9.2.7 Each was then subjected to the above tests. All three maintained their structural integrity.

2.9.3 Test Results

2.9.3.1 As the testing progressed it became increasingly apparent that the difficulty lay primarily in the incompatibility of the excessive coefficient of expansion of the stainless steel back cap and the heavy bead of epoxy with that of the quartz window. As the temperature decreased, the excessive contraction of the epoxy bead around the relatively stable dimension of the quartz caused the bead to crack. At extreme low temperatures, the excessive contraction of and consequent pressure by the stainless steel back cap caused the quartz window to break. The application of the bonding material, silver epoxy, in a glueline seal under the back cap only, rather than as a heavy bead eliminated the former problem. Changing the back cap material to Kovar rather than stainless steel eliminated the latter difficulty. Kovar is an iron, nickel, cobalt alloy having a coefficient of thermal expansion close to that of the quartz window.

2.9.4 Test Data

2.9.4.1 Test data obtained during these tests are tabulated in Tables 2 and 3.

TABLE 2. TEST DATA

Test	Quartz Body Dia.	Back Cap Inside Dia.	-150°F	-320°F	Bonding Agent	Back Cap Design	Remarks
1.	0.9985	1.003	o.k.	cracked	T120-3	1	
2.	1.003	1.005	cracked	-	T120-3	1	
3.	1.004	1.005	cracked	-	no adhesive	1	
4.		no cap	-	cracked	T120-3	none	no back cap
5.	1.004	1.005	cracked	-		1	
6.	1.003	1.005	-	cracked		1	
7.	1.004	1.006	o.k.	o.k.	no adhesive	1	
8.	-	-	-	broke	T120-3	none	no back cap
9.	1.004	1.006	-	broke	T120-3	1	3 spaces
10.	1.000	1.004	-	broke	Locktite Grade A	1	
11.	0.996	1.005	o.k.	o.k.	Sauereisen cement #29	1	
12.	0.998	1.006	-	broke	Sauereisen cement #29	1	
13.	-	-	-	broke	Sauereisen cement #29	2	
14.	1.005	1.004	o.k.	-	Sauereisen cement #29	3	broke under external pressure
15.	1.002	1.004	cracked	-	Sauereisen cement #29		
16.	1.001	1.006	cracked	-	T120-3	1	glueline epoxy under back cap
17.	1.001	1.006	o.k.	-	Sauereisen cement #29	4	
18.	1.000	1.005	o.k.	broke	Locktite Grade A	5	
19.	1.001	1.006	o.k.	o.k.	Locktite Grade A	6	glueline epoxy
20.	1.001	1.006	o.k.	o.k.	T120-3	6	blueline epoxy
21.	-	-	-	o.k.	3022	none	no back cap
22.	0.998	1.006	o.k.	o.k.	3022	6	glueline epoxy

Back Cap Design

1. Original - Stainless steel - thick wall
2. Stainless Steel - thick wall - six slots in wall
3. Stainless Steel - thin wall - six slots
4. Stainless Steel - thin wall - no slots
5. Stainless Steel - thick wall - eight slots
6. Kovar - original design

TABLE 3. BONDING AGENTS

Bonding Agent	Catalyst Parts by Weight	Agent Parts by Weight	Curing Temperature	Curing Time
T120-3	1	1	250°F	30 min.
3022	8	100	150°F	60 min.
Locktite	none	-	212°F	10 min.

NOTE: The bonding agent is mixed with the catalyst in the ratio shown in the above chart. The mixture is then applied as needed. The complete unit is placed in a clean oven to cure at the temperatures and for the times listed above. Property sheets for each bonding agent follows this page.

T120-3 - Poly Sulfide Epoxy
3022 - Silver Epoxy - Epoxy Products #3022
Locktite- Grade A

TECHNICAL INFORMATION

HOW IT WORKS:

LOCTITE sealant is a thin liquid that hardens into a tough plastic bond when confined between closely fitting metal parts.

The self-hardening property of LOCTITE which makes it unique among all other sealants and adhesives is based on two factors — (1) contact with air keeps LOCTITE liquid, and (2) metal surfaces hasten hardening. In joints between mating metal parts LOCTITE hardens rapidly because it is in close contact with metal and out of contact with air. *A film of LOCTITE on an exposed metal surface stays liquid as long as it is in contact with air.*

LOCTITE bonds all common metals, glass, ceramics, and phenolic plastics to themselves and to each other. Phenolic plastic parts and some plated metal parts require a priming rinse in degreasing solvent containing a hardening agent — our LOCQUIC activator. The locking action of LOCTITE extends over the whole engaged surface, resulting in a high breakloose torque. Even after the bond has been ruptured, the hardened plastic acts as a mechanical obstruction in the threads and develops a prevailing torque type of locking action which persists for several full turns (see Fig. 2).

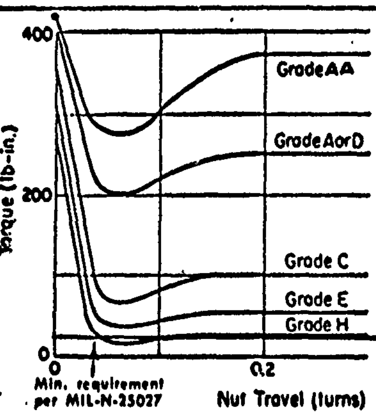

Fig. 2 — Locking Torques of 3/8-24 nuts tightened to 300 lb-in and treated with the different grades.

The prevailing torque, for the strongest grades, is many times as great as that of locknuts and lock screws. This combination of high breakloose torque and high prevailing torque makes threaded fasteners shock and vibration proof. Valuable production time is saved by the fact that treated parts spin *on* freely, lock *after* assembly.

LOCTITE is used on threaded fasteners, from tiny eyeglass screws up to 4" studs. LOCTITE reduces inventory problems since *one* bottle locks *all* sizes. LOCTITE locks fasteners in any position along the threads, whether seated or not, and is thus ideal for adjustment screws and nuts.

LOCTITE is used as a means of mounting bearings, replacing press fits. Avoids radial overloading of bearings. Easier tolerances speed assembly.

OTHER PROPERTIES

CURE TIME: 4 to 12 hours at 75°F depending on the metal. Heat hastens hardening which is complete in ten minutes at 212°F and in five minutes at 350°F. Many treated assemblies can be hardened in a few minutes by immersion in boiling water or by passage through a vapor phase degreaser which at the same time removes any excess LOCTITE outside the joint to be sealed. Room temperature hardening can be accelerated by priming parts with a LOCQUIC rinse.

OPERATING TEMPERATURE RANGE: —65°F to +300°F. Write for TDS #3.

SOLUBILITY: *Liquid* LOCTITE is soluble in trichloroethylene and most degreasing solvents. *Hardened* LOCTITE is insoluble — resists oil, water, gasoline, fuels MIL-1, MIL-111, JP-4, engine oils, MIL-0-6081, MIL-0-6082, MIL-L-7808, hydraulic fluids AN-0-366, Skydrol 7000, Freon, most chemicals. Use Grade A(10-1) for maximum resistance to solvents, chemicals, heat. For more information, write for TDS #2.

NON-TOXIC: No allergy.

THERMAL CYCLING: Withstands rapid thermal cycling from —65°F to +300°F.

FUNGUS RESISTANCE: Meets the requirements of MIL-E-5272A.

SOLVENT ACTION: Liquid LOCTITE does not affect thermoset plastics, phenolics, ureas, gum rubber, nylon, or polyethylene. It softens polystyrene, cellulosic and vinyl plastics, lacquered and varnished surfaces.

GEL TIME — less than ten minutes at 75°F.

FLASH POINT above 200°F. Non-volatile and non-flammable at room temperature.

VOLATILES Less than 5% in cured state. (per MIL-S-7196B).

CAUTIONS: To avoid spoilage do not contaminate large quantities of LOCTITE with metal dust or LOCQUIC. Pour from bottle into service dish for brushing, dipping applications. Avoid entry into moving parts. Test before using on organic finishes.

TABLE 3

SPECIFICATIONS

Grade	Color Code	Viscosity (centipoise)	Relative Torque	Shear Strength psi
AA (15-1)	Green	10-15	15	1150-1500
A (10-1)	Red	10-15	10	750-1000
D (10-4)	Orange	40-50	10	750-1000
AV (10-10)	Red	100-150	10	750-1000
B (7-2)	Yellow	20-30	7	525-700
C (4-1)	Blue	10-15	4	300-400
CV (4-10)	Blue	100-150	4	300-400
E (2-1)	Purple	10-15	2	150-200
EV (2-10)	Purple	100-150	2	150-200
H (1-1)	Brown	10-15	1	75-100
HV (1-10)	Brown	100-150	1	75-100

Also available in colorless as standard grades.

Use lower viscosities for fine threads and maximum penetrating ability; higher viscosities for coarse threads and for tumbling applications.

MILITARY STANDARD PART NUMBERS

LOCTITE Grade Identification	MIL-S-22473 Class No.	MIL-S-40083 Class No.	BUAER Dwg # 58A5A49- (dash nos.)	NAVORD Part # 12-Z-30403- (dash nos.)	BUORD Dwg # 1590004- (dash nos.)
A (10-1)	10	10	1	12	1
D (10-4)			3	14	3
AV (10-10)	11	11	6		
B (7-2)			11		
C (4-1)	20	20	2	13	2
CV (4-10)	21	21	8		
E (2-1)	30		4	15	4
EV (2-10)	31		12		
H (1-1)	40	30	5		
HV (1-10)	41	31	13		
LOCQUIC (concentrated)		58A5A50-1			
LOCQUIC (ready-to-use)		58A5A50-2			

MILITARY SPECIFICATIONS

MIL-S-22473 — *SEALING COMPOUNDS, RETAINING, SINGLE COMPONENT, METAL ACTIVATED.*
A specification prepared by U. S. Navy—BUSHIPS to cover the use of LOCTITE sealant for a wide range of locking and sealing applications.

MIL-S-40083 — *SEALING AND RETAINING, COMPOUNDS; THREAD, SINGLE COMPONENT.*
Army Ordnance has approved this specification on the characteristics and performance of LOCTITE sealant with regard to its use on threaded fasteners and fittings and for retaining bearings.

MIL-P-11268D — *PARTS, MATERIALS AND PROCESSES USED IN ELECTRONIC COMMUNICATION EQUIPMENT.*
LOCTITE sealant is called out as a preferred method of securing threaded fasteners.

LOCQUIC CLEANER

LOCQUIC is a priming rinse which may be used to speed the hardening of LOCTITE. Non-metallic parts require LOCQUIC rinse to activate surfaces for LOCTITE.. Some zinc and cadmium plated parts require LOCQUIC. Ready-to-use LOCQUIC is an effective cleaner for oily parts; concentrated LOCQUIC may be added to standard degreasing solvents.

T-120-3

HIGH-IMPACT RESISTANT ADHESIVE
Polysulfide Polymer/Epoxy Resin System

Description

Curable at either room temperature or elevated temperature, this adhesive bonds metals, wood, glass, plastics, ceramics, and other materials. The cured adhesive bond withstands high impact and thermal shock; also, it is resistant to many solvents, chemicals, oils and fuels.

Formulation

Part A	pbw	Part B	pbw
Polysulfide Polymer LP-3	100	TIPOX Resin B(2)	100
Burgess Pigment #20	64	Araldite 6020(3)	25
DMP-30(1)	10	Burgess Pigment #20	49

(1) Rohm and Haas Company
(2) Thiokol Chemical Corporation
(3) Ciba Company, Inc.

Mixing ratio: A/B parts by weight	1/1
Working life @ 80°F, hr.	0.5
Cure time @ 80°F	7 days
Optimum cure	0.5 hrs. @ 250°F

Mixing and Application

Immediately before use, combine the two components, Part A and Part B, and mix thoroughly.

The bonding surfaces should be dry and free of corrosion products, grease, oil or other contamination Special surface treatments may be required for certain materials. Apply the adhesive evenly (5-7 mil thickness) to each bonding surface. The components are joined while the adhesive is still wet.

The adhesive will cure at room temperature. However, to obtain optimum physical properties in minimum time curing for 0.5 hour @ 250°F is suggested.

PROPERTIES OF KOVAR

THERMAL EXPANSION SPECIFICATIONS

After annealing in hydrogen for one hour at 900 C and for 15 minutes at 1100 C, the average linear coefficients shall fall within the following limits:

Temperature Range	Average Lineal Coefficient of Thermal Expansion (cm/cm/°C x 10^{-6})
30 - 400 C	4.54 - 5.08
30 - 450 C	5.03 - 5.37

Typical expansion data for other temperatures are as follows:

Temperature Range	Average Lineal Coefficient of Thermal Expansion (cm/cm/°C x 10^{-6})
30 - 200 C	5.04
30 - 300 C	4.86
30 - 400 C	4.74
30 - 500 C	6.19
30 - 600 C	7.89
30 - 700 C	9.31
30 - 800 C	10.39
30 - 900 C	11.47

CHEMICAL COMPOSITION

Nickel	29% (nom.)
Cobalt	17% (nom.)
Iron	Remainder
Manganese	0.50% (max.)
Silicon	0.20% (max.)
Carbon	0.06% (max.)
Aluminum	0.10% (max.)
Magnesium	0.10% (max.)
Zirconium	0.10% (max.)
Titanium	0.10% (max.)

The total of aluminum, magnesium, zirconium and titanium shall not exceed 0.20%.

THERMAL PROPERTIES

Melting point	1450 C
Thermal conductivity (cal/sec/cc/°C @ 30 C)	.0395
(cal/sec/cc/°C @ 300 C)	.0485
Curie point	435 C
Specific heat (cal/gm/°C @ 0 C)	0.105
(cal/gm/°C @ 430 C)	0.155
Heat of fusion (cal/gm)	64
Vapor pressure (microns @ 1000 C)	10^{-2}
Transformation point (gamma to alpha phase)	Below minus 80 C

TENSILE PROPERTIES

Typical values listed in the table below represent results obtained at various temperatures with a strain rate of 800%/hr.

Specimens	Temp. of Test. °C	0.5% Yield Strength, PSI	Ultimate Strength, PSI	Breaking Strength, PSI	Uniform Elong. %	Total Elong. %	Red. of Area %
1	21	59,500	77,500	44,000	16.78	35.4	69.0
2	213	39,000	58,500	37,500	18.59	32.08	73.2
3	308	32,500	54,500	37,500	22.12	34.79	65.2
4	400	30,000	50,000	31,000	20.90	36.33	74.0
5	500	26,500	42,000	29,000	21.69	33.96	71.0
6	600	23,500	36,000	32,500	19.45	28.40	35.0
7	738	21,500	25,000	22,000	6.87	18.23	25.0
8	790	17,100	19,000	15,000	5.21	14.65	21.6

ELECTRICAL PROPERTIES

Specific resistance at 25 C—49 microhms cm (294 ohms/cir mil ft)

°C	Relative Resistivity
25	1.00
100	1.28
200	1.64
400	2.19
600	2.38

PHYSICAL CONSTANTS

Density	0.302 lbs./cu.in.
Annealed Temper (Rockwell Hardness)	B82 (max.)
Cold-Worked Temper (Rockwell Hardness)	B100 (max.)

MAGNETIC PROPERTIES

Magnetic Permeability

Magnetic Permeability	Flux Density (Gausses)
1000	500
2000	2000
3700	7000 (max. value)
2280	12000
213	17000

Magnetic Losses (Watts per Lb)

Thickness	10 Kilogausses 60 Cycles Sec.	10 Kilogausses 840 Cycles Sec.	[illegible] Kilogausses 5000 Cycles Sec.	[illegible] Kilogausses 10,000 Cycles Sec.
.010	1.05	23.4	16.6	41.0
.030	1.51			
.050	2.77			

Note: The values of the various properties are to be considered as nominal except where limits are shown.

EPOXY PRODUCTS
A DIVISION OF JOSEPH WALDMAN & SONS
137 Coit St., Irvington, N. J. • ESsex 5-6000

DATA SHEET

JULY 1961

#3022
CONDUCTIVE EPOXY CEMENT
ROOM CURING
(Formerly X-1163)

#3022 is an epoxy silver paste recommended for applications requiring low electrical resistance and good adhesive properties.

#3022 requires the addition of Hardener #18 to harden and cure.

#3022 may be cured at room temperature. The application of heat will accelerate and shorten the cure time.

Typical applications of #3022 are lead terminations, printed circuits and shielding on bases which will not withstand the elevated temperatures required for fired-on coatings or solders.

The resistivity of cured #3022 is approximately .005 OHM-CM. Shear strength of steel to steel at 25C is 1800 psi.

Mixing Instructions: To 100 parts #3022 by weight
Add 8 parts Hardener #18

The ratios of hardener and silver epoxy should be weighed carefully and mixed thoroughly to assure uniformity.

Pot Life: 50 gram batch at 25C - 2 to 3 hours.
Note: Mix in small quantities to use within pot life time.

Suggested Cure Schedule: At 25C - 24 hours
65C - 3 hours
85C - 1-1/2 hours

Storage: Keep in dry place. Shelf life of ingredients when not combined is approximately one year.

EPOXY PRODUCTS, INC. take every precaution in the manufacture of products and compilation of data. Since operating conditions in the fabricators plant are beyond our control, no guarantee can be given.

2.10 Combined Vibration and High-Low Temperature Test

2.10.1 General

2.10.1.1 The beacon antenna must survive periods of time under conditions of temperature extremes in conjunction with the forces applied as a result of random vibrations generated within the Apollo Vehicle. These conditions were simulated in the test laboratory in an effort to verify the design strength and survivability of the proposed antenna design. Two antennas were tested; a Type II and a Type V.

2.10.2 Test Procedure

2.10.2.1 The antenna to be tested was mounted in a vibration fixture designed to simulate the command module mounting configuration. This fixture had an acceleration gain of less than 1.5:1 across the frequency band of 5 to 2000 cycles per second. The fixture was mounted atop an electrodynamic vibration exciter and simultaneously located within a temperature chamber capable of attaining the required temperature limits.

2.10.2.2 The antenna temperature was first raised to plus 250°F and permitted to stabilize. After the antenna temperature had stabilized at plus 250°F, five (5) one (1) minute bursts of random vibration at a spectral power density of 0.005 g^2/cps across a bandwidth of 5 to 2000 cycles per second were applied to the antenna. This random vibration was applied in the most sensitive axis, perpendicular to the longest axis of the antenna quartz cylinder. At the conclusion of these five (5) one (1) minute bursts, the spectral power density was doubled. While still stabilized at plus 250°F, the antenna was then subjected to one (1) two (2) minute burst of random vibration at a level of 0.01 g^2/cps across a bandwidth of 5 to 2000 cycles per second. The spectral power density was doubled as a check for a safety factor of at least two (2) to one (1).

2.10.2.3 At the conclusion of the two-minute bursts of random vibration, the antenna temperature was lowered to minus 150°F and permitted to stabilize. When the antenna temperature had stabilized at minus 150°F, five (5) one (1) minute bursts of random vibration were applied to the antenna in the most sensitive axis, perpendicular to the longest axis of the quartz cylinder. The spectral power density of the vibratory forces were 0.001 g^2/cps across a bandwidth of 5 to 2000 cycles per second. With the antenna still stabilized at minus 150°F a two (2) minute burst of random vibration was applied to the antenna in the same direction. The spectral power density of this burst was 0.01 g^2/cps across a bandwidth of 5 to 2000 cycles per second.

2.10.2.4 Heating of the antenna was accomplished by the use of electric heaters and forced air circulation. The time to increase the antenna temperature from room ambient to plus 250°F and to stabilize was approximately 1.5 hours. Cooling for the antenna negative temperature transition was accomplished through the use of direct expansion of liquid nitrogen and forced air circulation. The transition time from room ambient to minus 150°F, including sufficient time for the antenna temperature to stabilize, was approximately 2 hours.

2.10.2.5 A VSWR reading was taken prior to the start of testing with the antenna mounted directly on the slotted line. A VSWR reading was also taken with the antenna mounted in the vibration fixture on the shaker head in the temperature chamber with the door closed. This second reading was used as the reference for the rest of the test. The antenna VSWR was monitored during the entire test for any changes that might indicate physical change of or degradation to the antenna. See Figure 32.

2.10.3 Test Results

2.10.3.1 All VSWR readings, during and after testing, remained below the specification limit of 1.5:1. Both type antennas showed an increase in VSWR at mid-band frequency (5725 mc.) of approximately 0.20 units during the low temperature portion of this test.

2.10.3.2 At the conclusion of the tests both antennas were inspected for physical change. After testing, the Type V antenna exhibited a crack in the quartz window. This particular material was pin pointed to a contaminated lot which had been designated for use in development testing only. This material was used rather than destroyed owing to the great difficulty in obtaining quartz for the antenna windows. The clamp rings were of an obsolete design which required extreme care to prevent excessive and uneven loading during assembly. A subsequent test was performed with an antenna model Type V using all production parts and was successfully completed.

2.10.3.3 The Lefkoweld bond, while maintaining its integrity, showed many hairline cracks. This aroused suspicion of the back cap bonding technique. An investigation later was performed and both the bonding material and back cap material were changed.

DATA SHEET P-20013

NO: 6232A

APOLLO C BAND BEACON ANTENNA

Test Location: General Testing Labs Date: 1/20/65 and 1/21/65

Test Personnel: Williams & Freedman Signature:

S/N: Type II - Developmental Model Signature:

Freq. (mc)	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10		
5640	1.48	1.11	1.08	1.08	1.08	1.14	1.10	1.10	1.10	1.11		
5725	1.30	1.19	1.16	1.16	1.14	1.43	1.49	1.50	1.50	1.38		
5815	1.49	1.08	1.16	1.16	1.16	1.26	1.45	1.44	1.44	1.28		
Time	1:00	1:45	2:50	3:00	3:10	1:05	3:00	3:10	3:15	4:15		

Notes:

- All readings are VSWR

#1 - Ambient Conditions - On Slotted Line

#2 - Ambient Conditions - In Chamber, On Fixture, Door Closed - Reference

#3 - Plus 250° F - No Vibration

#4 - Plus 250° F - 5, 1-minute Random Vibration 5-20 cps .005g^2/cps

#5 - Plus 250° F - 2 minutes Random Vibration 5-20 cps .01g^2/cps

#6 - Ambient Conditions - In Chamber, Door Closed - Reference - Next Day

#7 - Minus 150° F - No Vibration

#8 - Minus 150° F - 5, 1-minute Random Vibration 5-2- cps .005g^2/cps

#9 - Minus 150° F - 2 minutes Random Vibration .01g^2/cps

#10 - Ambient - Temperature obtained by heating

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Silver Spring, Maryland

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Figure 30. Data Sheet, Type II

DATA SHEET

P-20013

NO: 6232A

APOLLO C BAND BEACON ANTENNA

Test Location: General Testing Labs
Date: 1/21/65 and 1/22/65
Test Personnel: Williams
Signature:
S/N: Type V - Developmental Model
Signature:

Freq. (mc)	#1	#2	#3	#4	#5	#6	#7	#8				
5640	1.52	1.28	1.40	1.43	1.48	1.14	1.15	1.20				
5725	1.30	1.16	1.12	1.14	1.14	1.43	1.43	1.48				
5815	1.30	1.07	1.08	1.08	1.27	1.12	1.14	1.18				
Time	4:20	9:20	10:35	10:45	11:10	12:30	1:00	1:10				

Notes:

*All readings ar VSWR

#1 - Ambient - On Slotted Line

#2 --In Chamber, Door Closed - Reference

#3 - Plus 250° F - No Vibration

#4 - Plus 250° F - 5, 1-minute bursts Random Vibration 5-20 cps .005g^2/cps

#5 - Plus 250° F - 2 minutes Random Vibration 5-20 cps .01g^2/cps

#6 - Minus 150° F - No Vibration

#7 - Minus 150° F - .005g^2/cps Random Vibration

#8 - Minus 150° F - .01g^2/cps Randmm Vibration

No room ambient redding was taken after completion of the tests. Upon dismantling the antenna for removal from the test fixture, a physical inspection showed the quartz cylinder had broken into two pieces. The crack occured under the graphite clamp.

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Silver Spring, Maryland

SHEET	SPEC. NO.	REV.
19A	6232	

Figure 31. Data Sheet, Type V

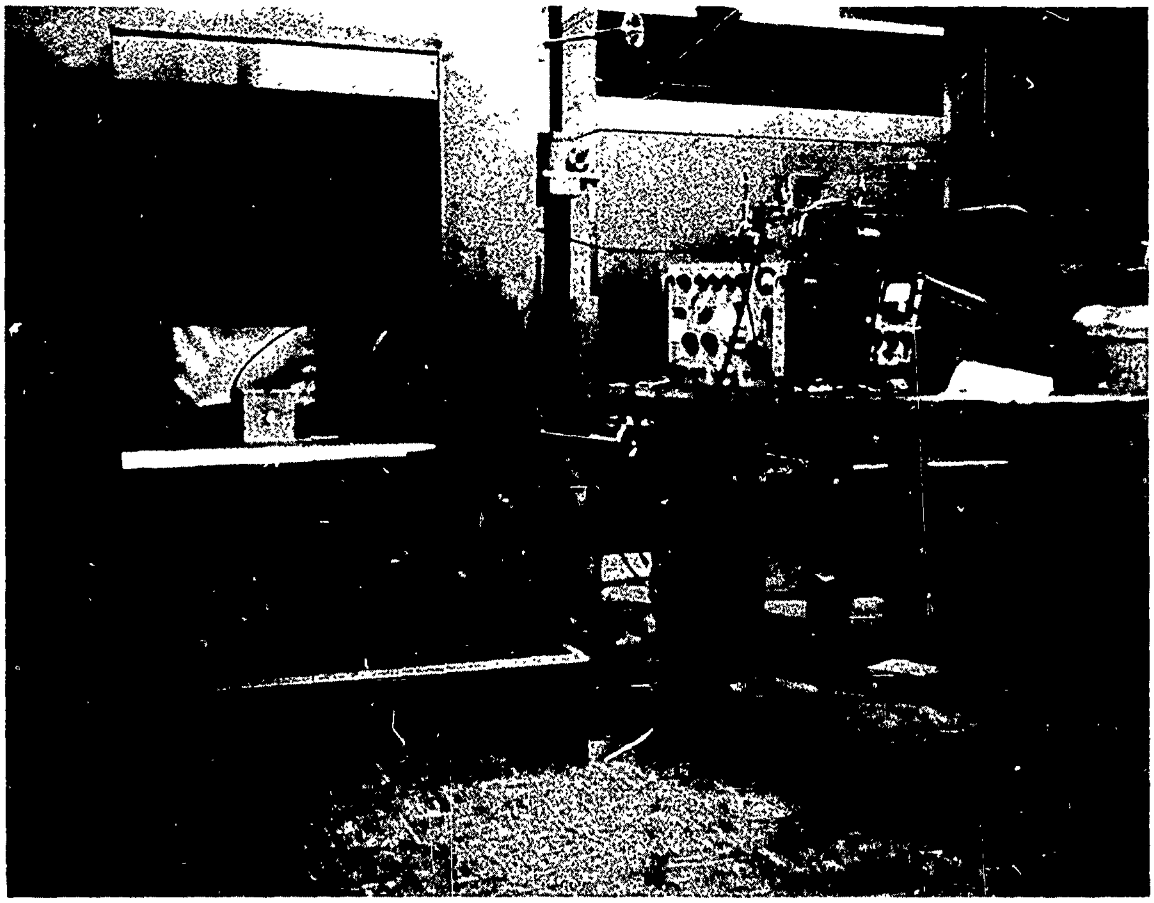

Figure 32. Vibration, Temperature and Humidity Testing

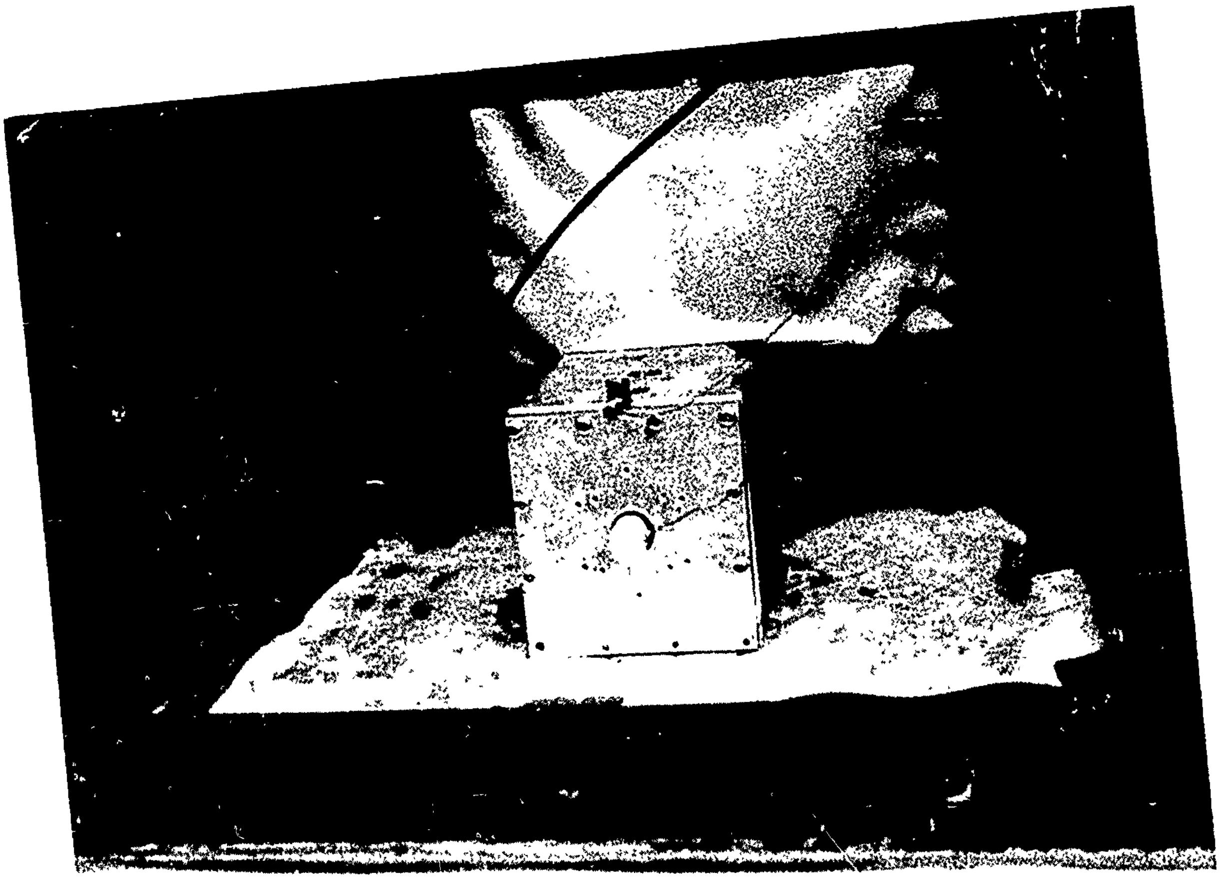

Figure 33. Vibration Test Fixture

Figure 34. VSWR and Axial Ratio Measurement

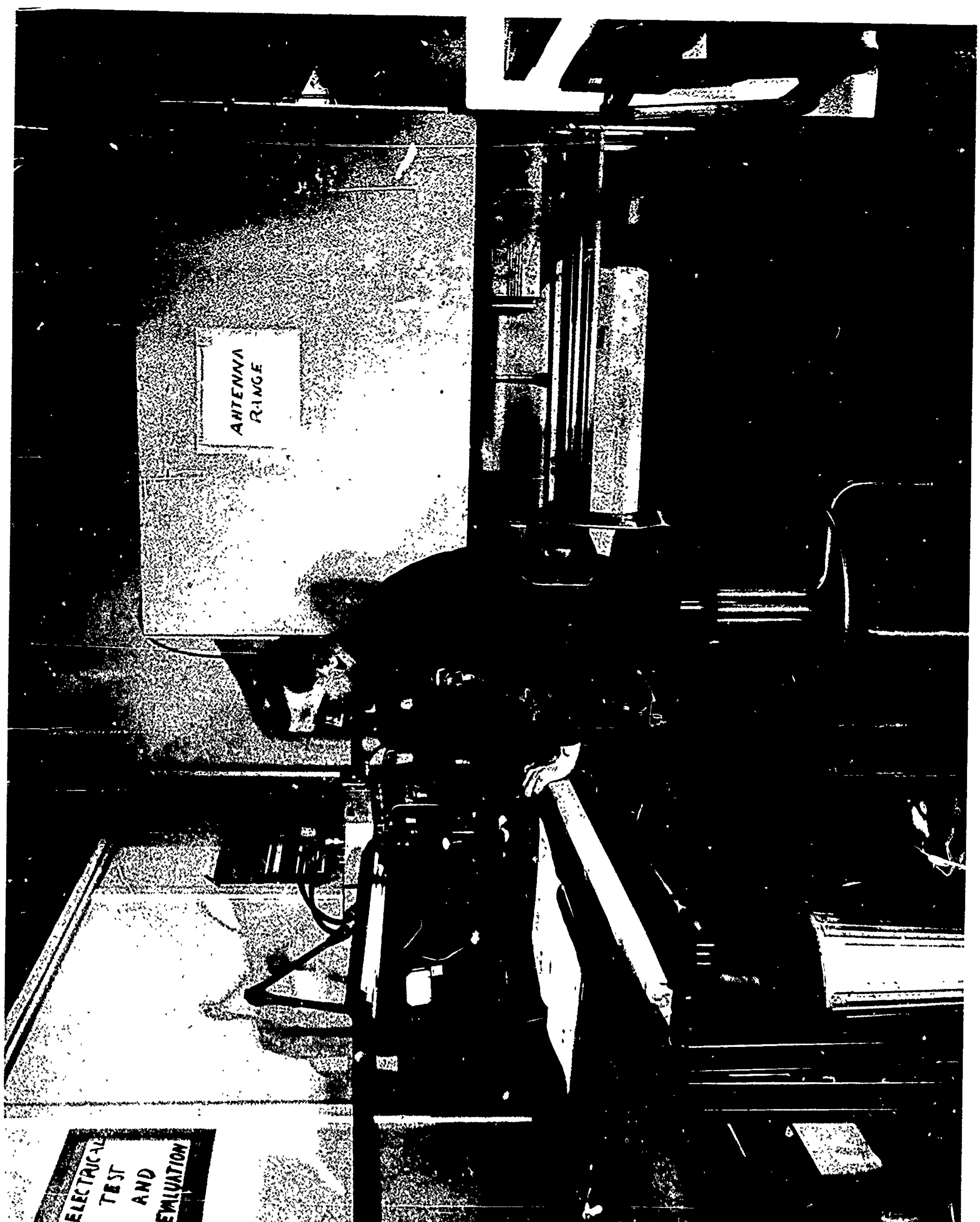

Figure 35. VSWR Measurement

2.11 Humidity Test

2.11.1 General

2.11.1.1 The Apollo Beacon Antenna may be stored or placed in a stand-by condition in an unpredictable ambient atmosphere over extended periods of time. The temperature could exceed 100°F while the relative humidity could go as high as 95 percent. The following test was conducted to determine the resistance of the materials of which the antenna is constructed to these atmospheric conditions. Neither the physical strength nor the electrical properties of the antenna should be affected.

2.11.2 Test Procedure

2.11.2.1 One Type II and one Type V antenna were subjected to two cycles of the humidity test specified in MIL-STD-810. The antennas' electrical connectors were covered with a soft plastic cap during the entire two cycles. The antennas were placed on a wooden shelf within the test chamber with the temperature and relative humidity at room ambient. Over a two hour period, the temperature was gradually raised to plus 160°F and the relative humidity was gradually raised to 95 percent. These conditions were maintained for a period of six hours. At the conclusion of these six hours, the chamber temperature was gradually reduced to room ambient while the relative humidity was maintained at 95 percent. This comprised one cycle of the test. Upon completion of the cycle the entire test was taken through a second cycle.

2.11.3 Test Results

2.11.3.1 The VSWR of both antennas was measured before and after each test. In both cases the VSWR remained constant and below the 1.5:1 limit. However, upon attaching the Type V antenna to the slotted line the Lefkoweld bond separated from the stainless steel back cap. An investigation was subsequently conducted upon the back cap and bonding element materials and design. New materials and techniques were incorporated and additional humidity testing proved the antenna capable of withstanding the imposed environment with no physical or electrical degradation.

Figure 36. Humidity and Temperature Testing

DO NOT MICROFILM

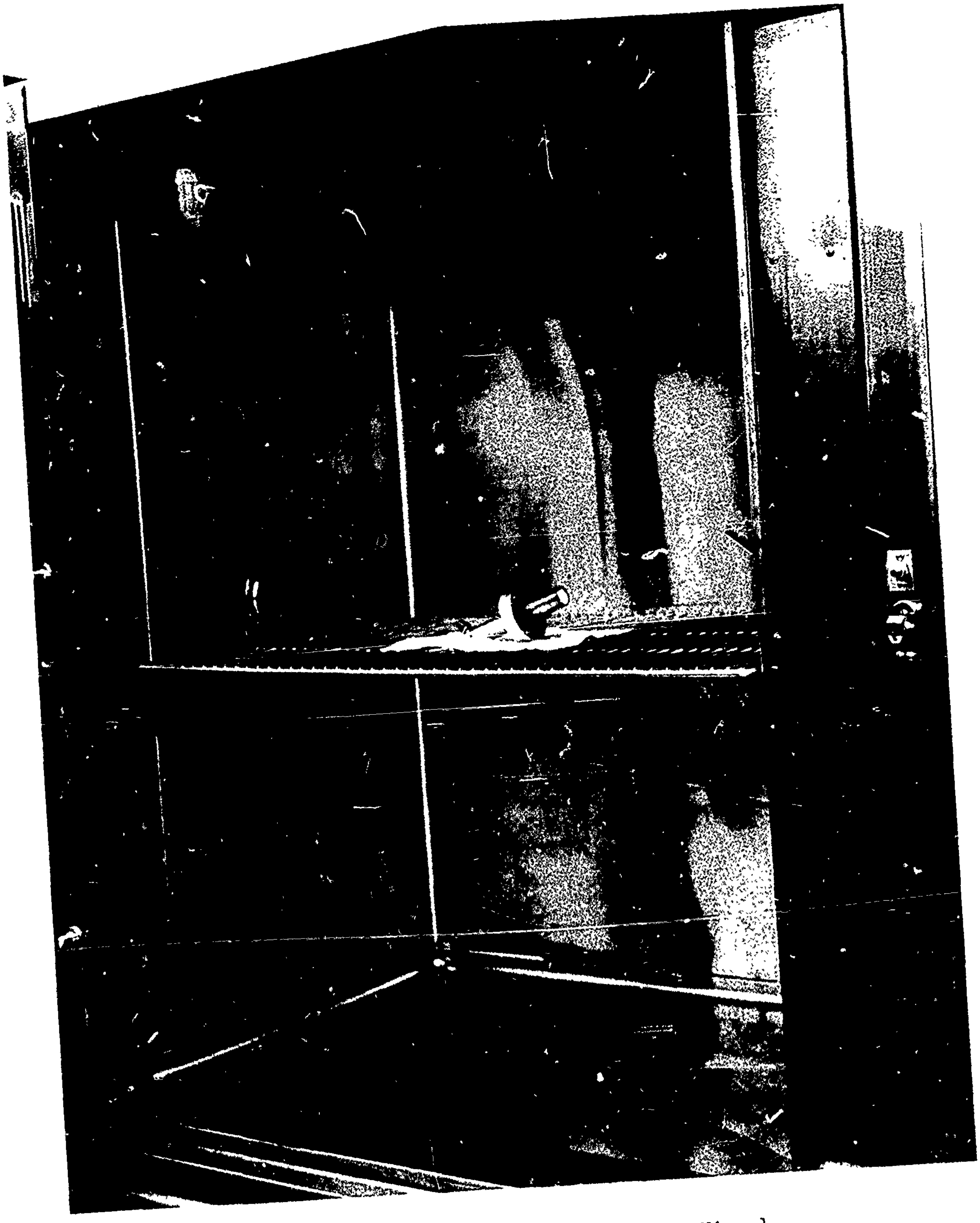

Figure 37. Humidity Test Set-Up, View 1

DO NOT MICROFILM

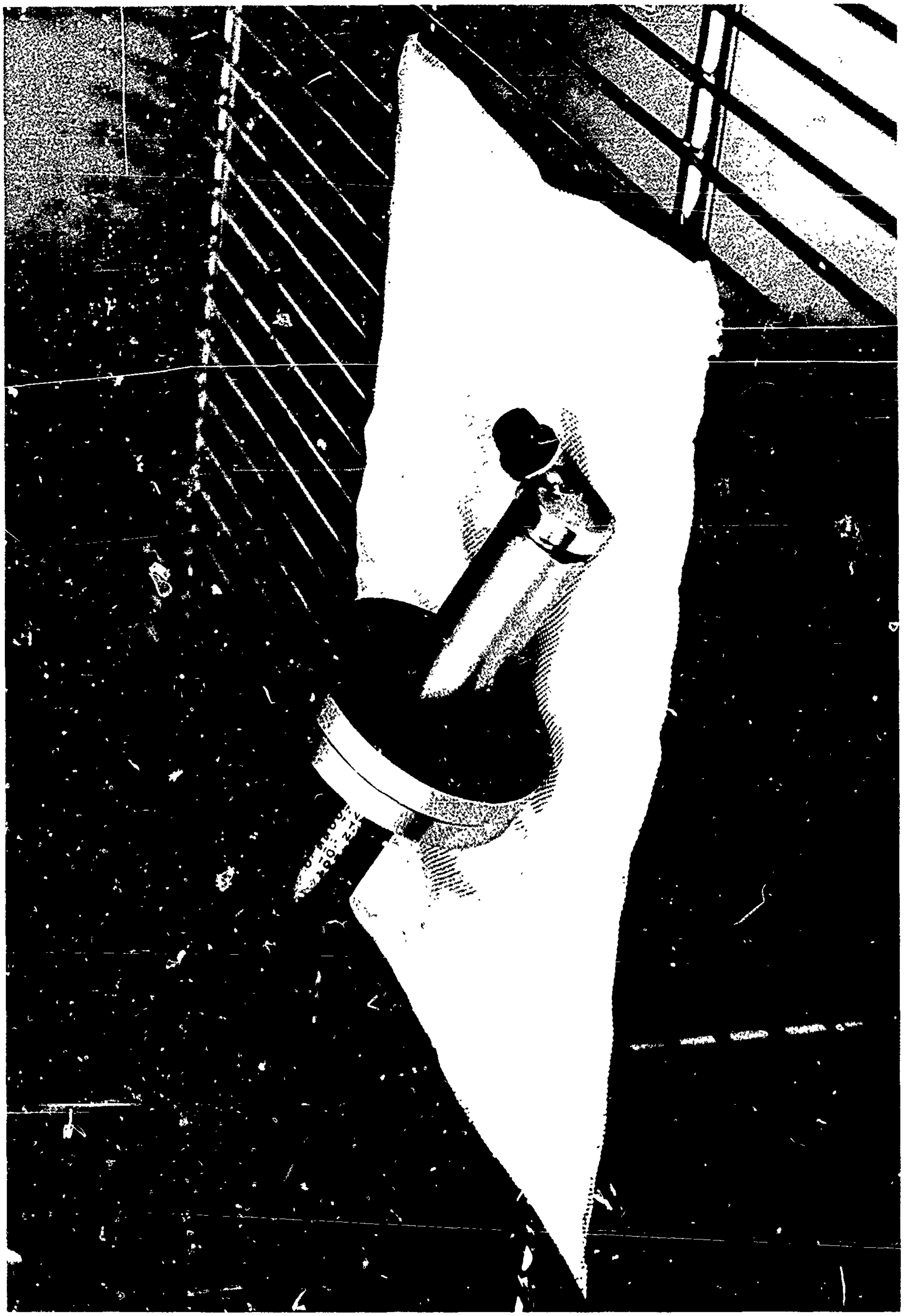

Figure 38. Humidity Test Set-Up, View 2

2.12 Random Vibration Test

2.12.1 General

2.12.1.1 Of the many forces which will be exerted on the beacon antenna, some will be of a vibratory nature. These will be applied at a temperature in the range of the ground ambient. The following series of random vibration tests were performed to check out the antenna design under these conditions.

2.12.2 Test Procedure

2.12.2.1 During all of these tests the antennas were mounted in a vibration fixture designed to simulate the command module mounting configuration. The vibration test fixture had no resonances exhibiting an acceleration gain in excess of 1.5:1 across the frequency band of 5 to 2000 cycles per second. All applied random vibration was in the frequency band of 5 to 2000 cycles per second. The VSWR of all antennas was measured before, after, and at intervals during the applied vibration.

2.12.2.2 One Type V antenna, serial number 3, was subjected to random vibration which was applied parallel to the axis of the antenna for a period of 15 minutes. The vibration was applied starting at 10G's (RMS) and gradually increased to 30G's (RMS).

2.12.2.3 One Type II antenna, serial number 3, was subjected to random vibration applied parallel to the axis of the antenna. The applied vibration level was 37G's (RMS).

2.12.2.4 One Type V antenna, serial number 4, was subjected to random vibration applied parallel to the axis of the antenna for a period of 15 minutes. The vibration was applied starting at 10G's (RMS) and increased gradually to 65G's (RMS).

2.12.2.5 One Type II antenna, serial number 1, was subjected to random vibration applied parallel to the axis of the antenna for a period of 15 minutes. The vibration was applied starting at 37G's (RMS).

2.12.3 Test Results

2.12.3.1 No meaningful changes in VSWR were noted in any of the antenna during or after testing.

2.12.3.2 At 28G's (RMS) the sintered quartz window of antenna serial number 3, Type V, started walking in its graphite clamp. The 28G figure represents a level of 2.8 times that required.

2.12.3.3 At 65G's (RMS) the sintered quartz window of antenna serial number 4, Type V started walking in its graphite clamp. The 65G figure represents a level of 6.5 times that required.

2.12.3.4 At 75G's (RMS) the Lefkoweld seal around the perimeter of the back cap cracked. This represents a level 7 times that required.

DATA SHEET #5 P-20013

NO: 6232A

APOLLO C BAND BEACON ANTENNA

Test Location: General Testing Labs. Moonachie, N. J. Date: 2-10-65

Test Personnel: Williams & Freedman Signature: I. Freedman

S/N: #3 Type V: Development Model Signature:

Freq. (mc)	1	2	3.	4	5							
5640	1.25	1.25	1.26	1.26	1.32							
5725	1.26	1.26	1.26	1.26	1.30							
5815	1.22	1.22	1.22	1.21	1.15							
Time	9:08p	9:12p	9:17p	9:22p	9:27p							

Notes:

- All Readings are VSWR

1. Vibration - 10 G's (rms)
2. Vibration - 20 G's (rms)
3. Vibration - 30 G's (rms) - antenna walled in clamp.
4. Vibration - gradual increase from 20 G's to find level at which antenna started to walk. Walking started at 28 G's (rms)
5. Ambient Conditions - Antenna on slotted line.

No visible physical damage to antenna.

Vibration parallel to antenna axis.

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Figure 39. Data Sheet No. 1 of Random Vibration Test

DATA SHEET #6 P-20013

NO: 6232A

APOLLO C BAND BEACON ANTENNA

Test Location: General Testing Labs. Moonachie, N. J. Date: 2-10-65

Test Personnel: Williams & Freedman Signature: I. Freedman

S/N: #3 Type II: Development Model Signature:

Freq. (mc)	1	2	3	4	5	6						
5640	1.56	1.22	1.19	1.19	1.20	1.63						
5725	1.49	1.22	1.22	1.21	1.23	1.49						
5815	1.46	1.18	1.18	1.17	1.18	1.49						
Time	9:34p	9:42p	9:46p	9:51p	10:00p	10:09p						

Notes:

- All Readings are VSWR

1. Ambient Conditions - antenna on slotted line
2. Ambient Conditions - Antenna mounted on holding fixture
3. Vibration Only - 37 G's (rms)
4. Vibration Only - 37 G's (rms)
5. Vibration Only - 37 G's (rms)
6. Ambient Conditions - Antenna on slotted line

No visible damage to antenna.

Vibration parallel to antenna axis.

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SHEET 19A OF SPEC. NO. 6232 REV.

Figure 40. Data Sheet No. 2 of Random Vibration Test

DATA SHEET #7 **P-20013**

NO: 6232A

APOLLO C BAND BEACON ANTENNA

Test Location: General Testing Labs. Moonachie, N. J. **Date:** 2-11-65

Test Personnel: Williams & Freedman **Signature:** I. Freedman

S/N: #4 Type V: Development Model **Signature:**

Freq. (mc)	1	2	3	4	5	6	7	8	9			
5640	1.64	1.26	1.27	1.26	1.26	1.27	1.27	1.65	1.22			
5725	1.20	1.29	1.29	1.30	1.29	1.29	1.30	1.26	1.28			
5815	1.42	1.25	1.24	1.24	1.23	1.24	1.24	1.42	1.24			
Time	9:40a	10:00a	10:02a	10:07a	10:11a	10:14a	10:19a	10:22a	10:28a			

Notes:

All Readings are VSWR

Vibration parallel to axis of antenna

1. Ambient Conditions - antenna on slotted line.
2. Ambient Conditions - Antenna in holding fixture
3. Vibration Only - 10 G's (rms)
4. Vibration Only - 20 G's (rms)
5. Vibration Only - 30 G's (rms)
6. Vibration Only - 40 G's (rms)
7. Vibration Only - 50 G's (rms)
8. Ambient Conditions - Antenna on slotted line.
9. Vibration Only - 65 G's (rms) - Quartz cylinder started to walk in graphite clamp.

No visible damage to antenna

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SHEET 19A SPEC. NO. 6232 REV.

RE6503 (5-63)

Figure 41. Data Sheet No. 3 of Vibration Test

DATA SHEET #8 **P-20013**

NO: 6232A
APOLLO C BAND BEACON ANTENNA

Test Location: General Testing Lab. Moonachie, N. J. **Date:** 2-11-65
Test Personnel: Williams & Freedman **Signature:** I. Freedman
S/N: #1 Type II: Development Model **Signature:**

Freq. (mc)	1	2	3	4	5	6	7	8				
5640	1.29	1.22		1.20	1.23	1.22	1.23	1.39				
5725	1.42	1.22	1.22	1.25	1.22	1.23	1.24	1.43				
5815	1.57	1.18	1.18	1.17	1.19	1.18	1.18	1.61				
Time	10:30a	10:50a	10:51a	10:55a	10:58a		11:03a	11:17a				

Notes:

All Readings are VSWR

Vibration Parallel to Axis of Antenna

1. Ambient Condition - Antenna on slotted line.
2. Ambient Condition - Antenna in holding fixture.
3. Vibration Only - 37 G's (rms)
4. Vibration Only - 50 G's (rms)
5. Vibration Only - 60 G's (rms)
6. Vibration Only - 65 G's (rms)
7. Vibration Only - 70 G's (rms)
8. Ambient Conditions - Antenna on slotted line.

Lefkoweld seal cracked.

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LITTON SYSTEMS, INC.
Silver Spring, Maryland

SHEET 19A	SPEC. NO. 6232	REV.

RE0800 (5-63)

Figure 42. Data Sheet No. 4 of Random Vibration Test

2.13 Compression Tests

2.13.1 General

2.13.1.1 Considerable testing associated with the Development Test Program has without exception attested to the adequacy of the mounting flange design. The sundry tests have included exposure to cryogenic environmental conditions by submersion in liquid nitrogen baths, thermal shock, vibration and combined vibration and temperature.

2.13.1.2 The object of these tests was to verify the design capability to comply with the NAA/S&ID specification MC 481-0005. In virtually all test cases, test levels beyond the contract requirements were chosen as an additional assurance factor. In all of the testing, the quartz body was securely held (i.e., no movement).

2.13.1.3 The effectiveness of the holding arrangement on the quartz body has been displayed on numerous occasions. As an example in the testing of the epoxy bonding of the Invar back cap to the quartz body, loads of upwards to 600 pounds were substained.

2.13.1.4 Not withstanding the previous testing, engineering initiated tests to ascertain the effectiveness of the holding device at elevated temperatures.

2.13.2 Test Procedure

2.13.2.1 Seven tests were run to determine the holding ability of the mounting flanges at high temperature. The test set-up is shown in figures 43 and 44. The results of the tests are shown in figures 45 thru 51 with the points at which movement of the flange occurred so indicated. A Thwing Tensile Testor was used to apply the load required to move the quartz body and the results were recorded on strip charts.

2.13.2.2 Six of the test specimens were comprised of representative production parts but in test number 4 stainless steel was substituted for aluminum. In test number 4 only four assembly flange screws were used. In the remaining six tests, four assembly flange screws and four air frame flange screws were used.

2.13.2.3 The Platinum coated quartz surface was polished in all of the tests with the exception of tests number 4 and 7. The Platinum coated quartz surface was left in a roughened state in tests number 4 and 7.

2.13.2.4 The inside diameter of the graphite clamp was .001" - .002" larger than the outside diameter of the quartz body in test numbers 1, 2, 4 and 5. The fit of the graphite to the quartz body was line to line in test numbers 6 and 7.

2.13.2.5 Test units 6 and 7 were submerged in a liquid nitrogen bath (-320°F).

2.13.3 Test Results

2.13.3.1 While the seven tests are not sufficient enough to be conclusive, some significant observations can be made.

2.13.3.2 There were no advantages noted by having the Platinum coating in a rough state as opposed to the polished Platinum. In actuality, the polished specimen in test number 6 sustained greater loads than the rough coated Platinum specimen in test number 7.

2.13.3.3 The stainless steel flanged specimen in test number 4 should be less susceptible to temperature gradients (thermal expansion).

2.13.3.4 The major factor to greater holding effectiveness is achieved by intimate contact of the graphite clamp around the entire quartz body. This is evident in test number 3 (line to line fit) and test numbers 6 and 7 where an interference fit existed.

2.13.3.5 The fixture contributed an additional weight of four pounds (load) which is not included in the test results.

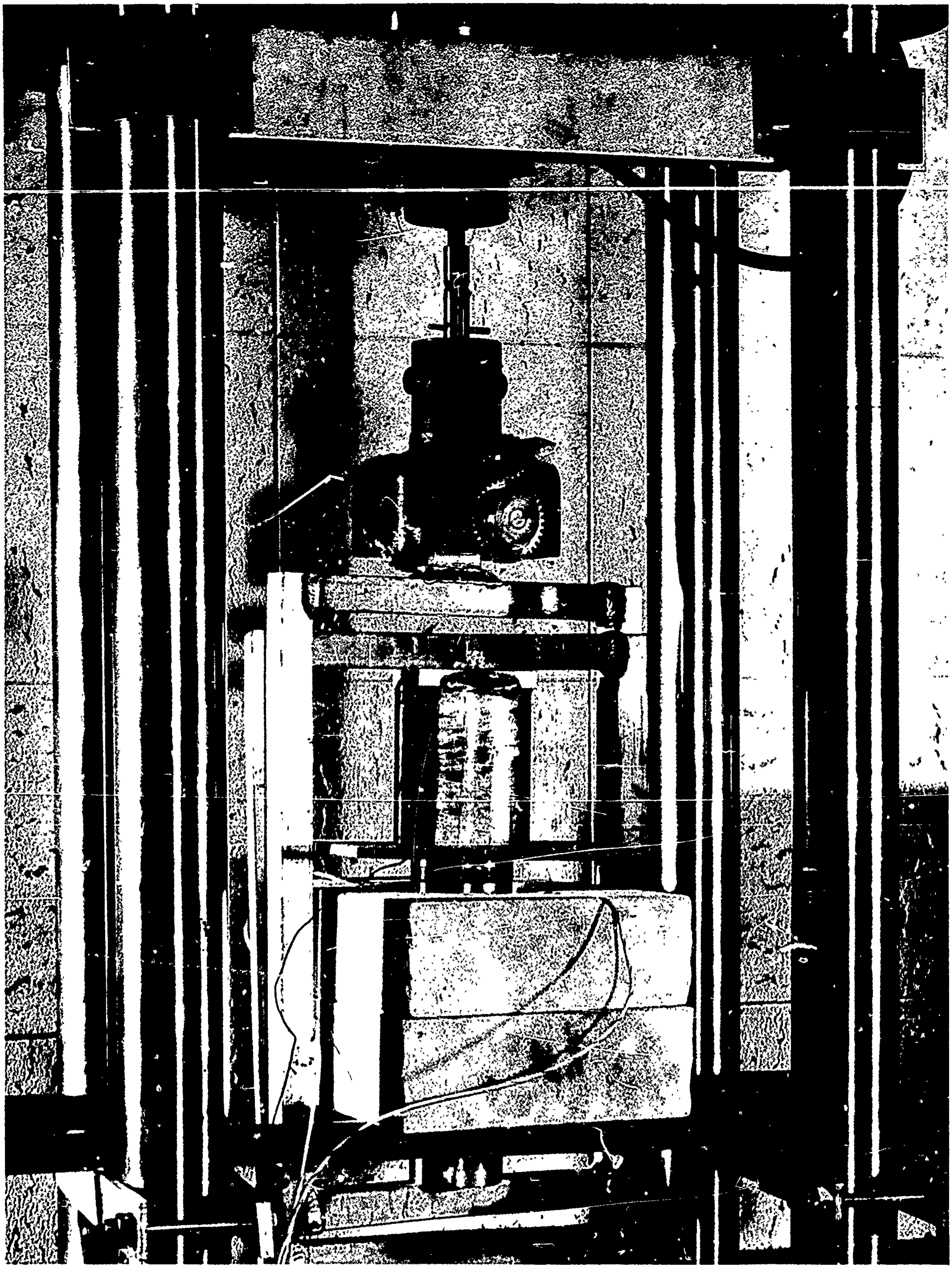
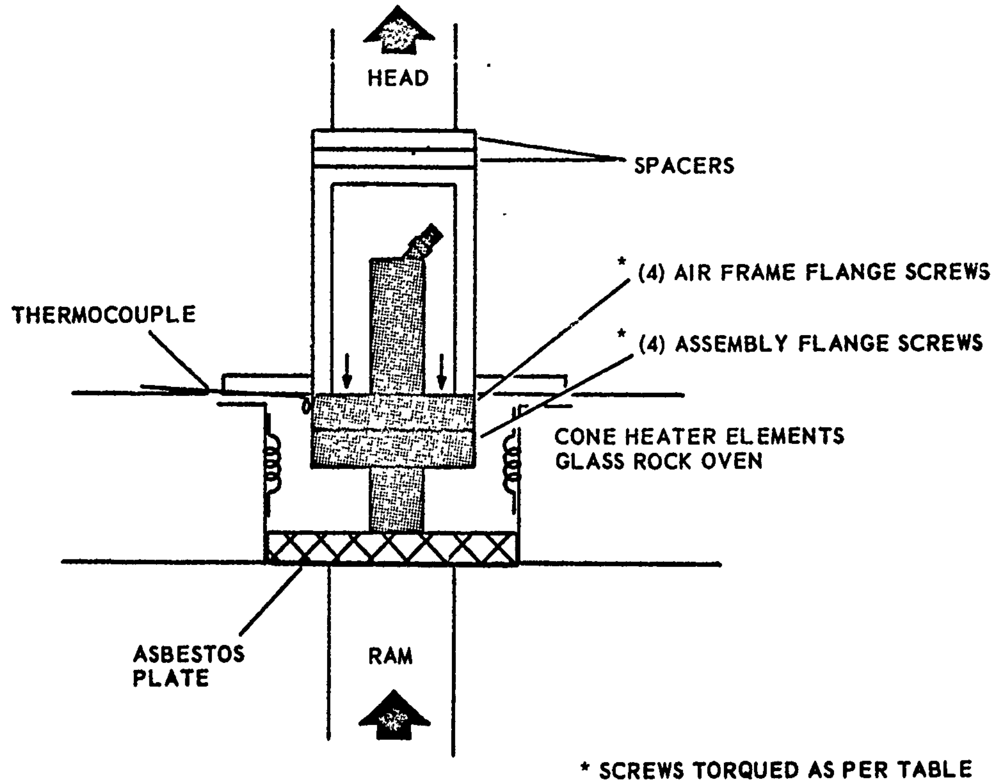


Figure 43. Compression Test Set-Up



FLANGE MOVEMENT TEST

TORQUE / IN LBS	TEST SERIES 1	2	3	4	5	6	7
AIR FLANGE SCREWS	20	20	15	—	30	30	30
ASSEMBLY FLANGE SCREWS	15	15	15	15	15	15	15

Figure 44. Compression Test Set-Up, Diagram

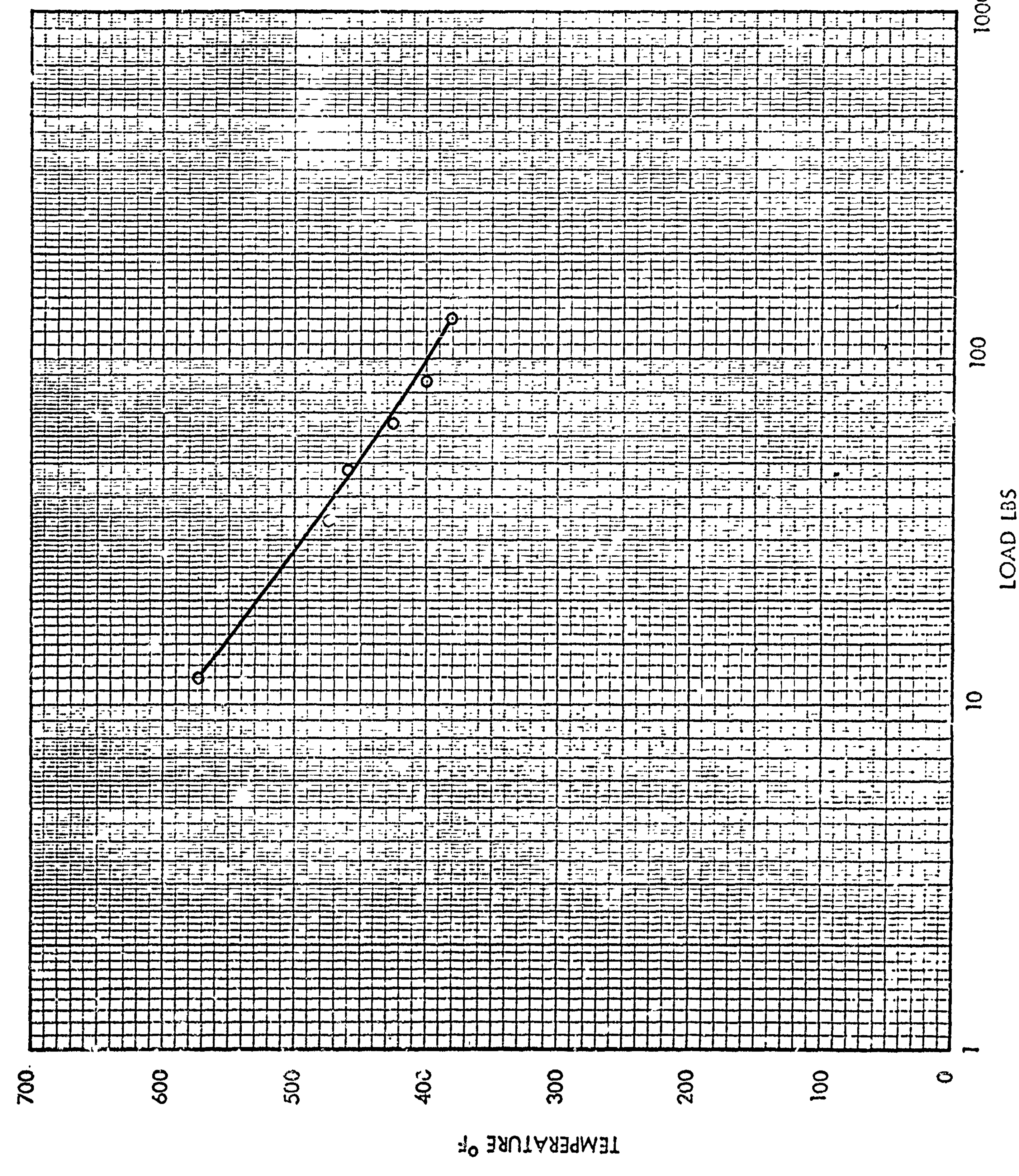


Figure 45. Test Number 1

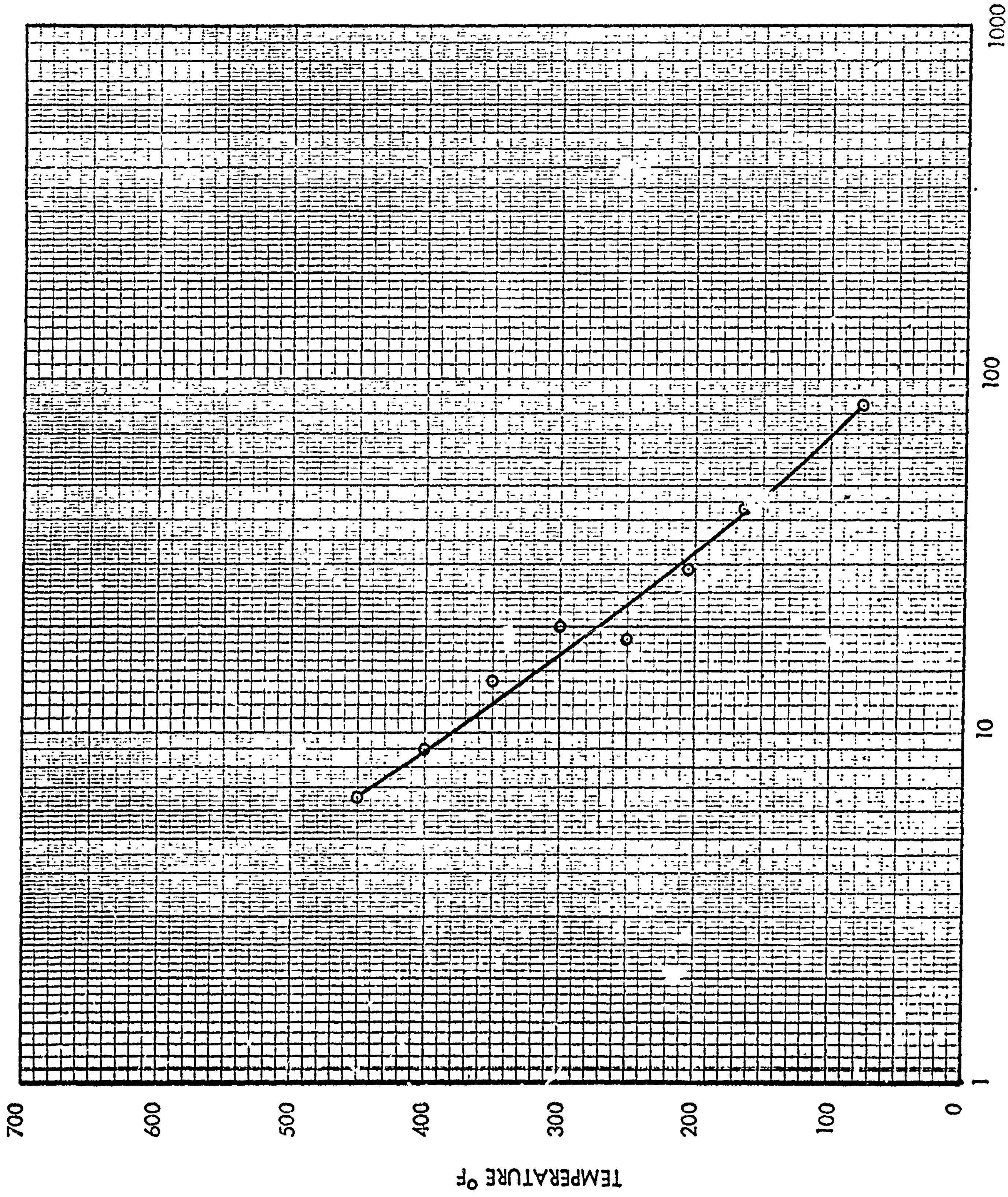


Figure 46. Test Number 2

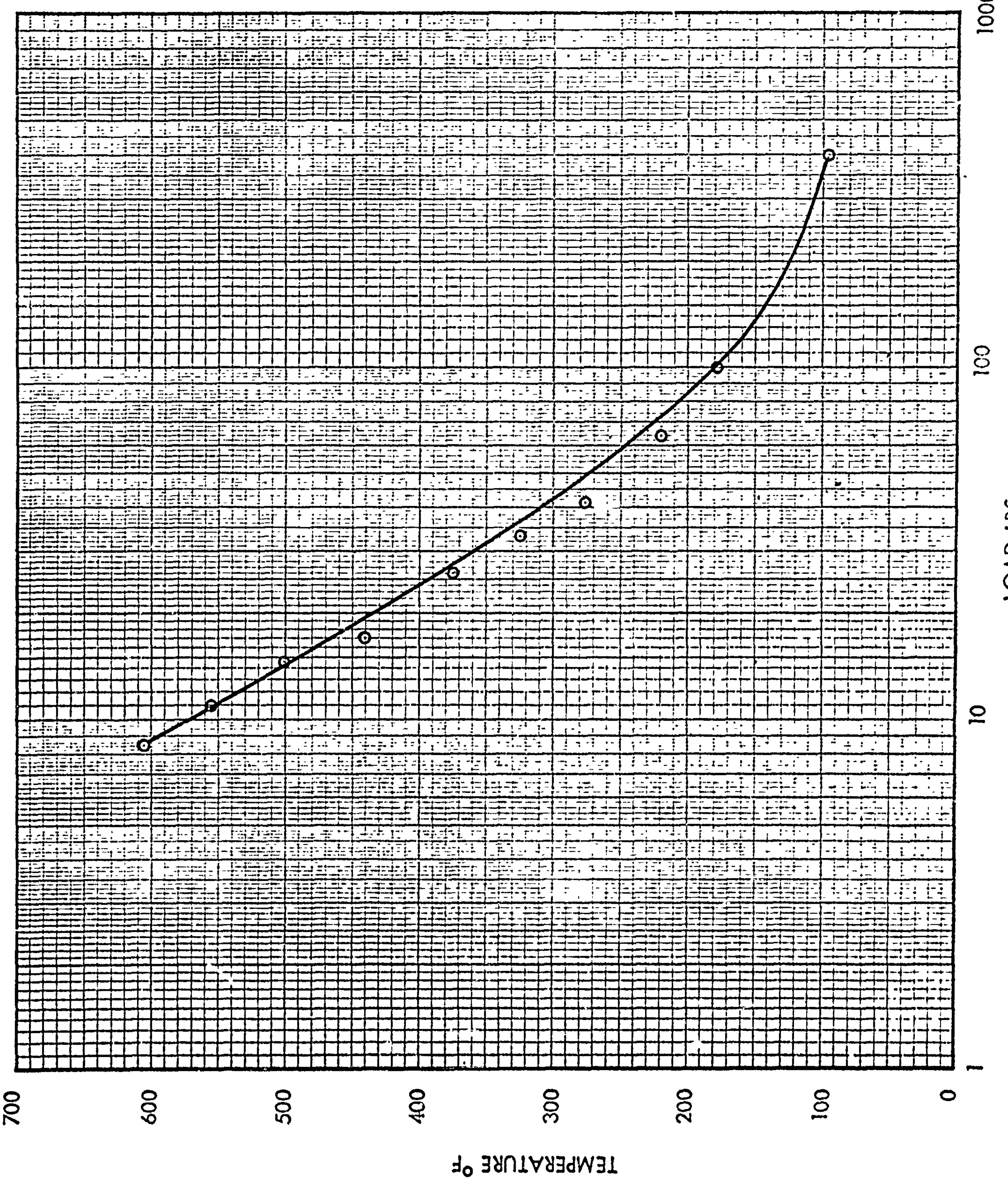


Figure 47. Test Number 3

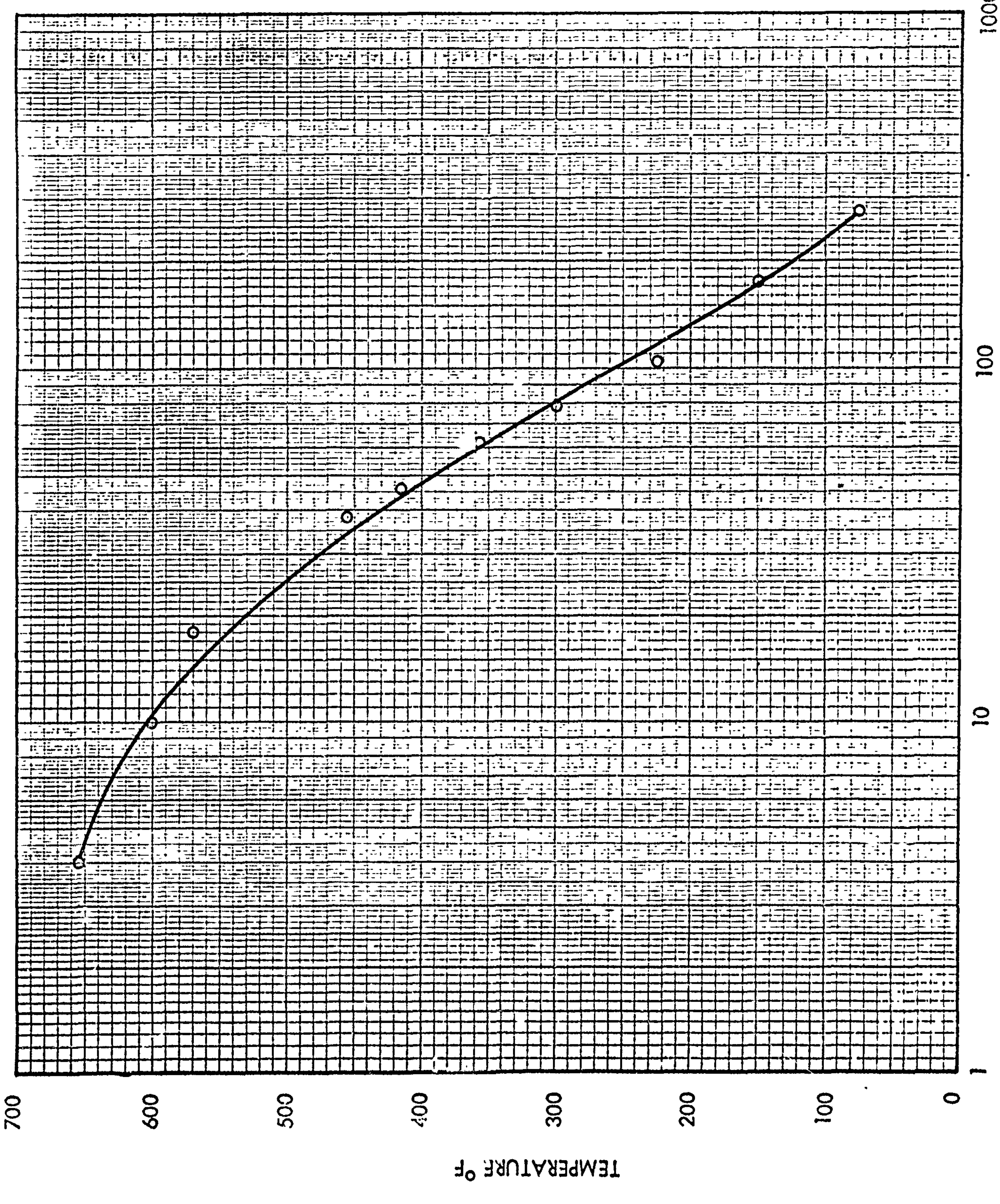


Figure 48. Test Number 4

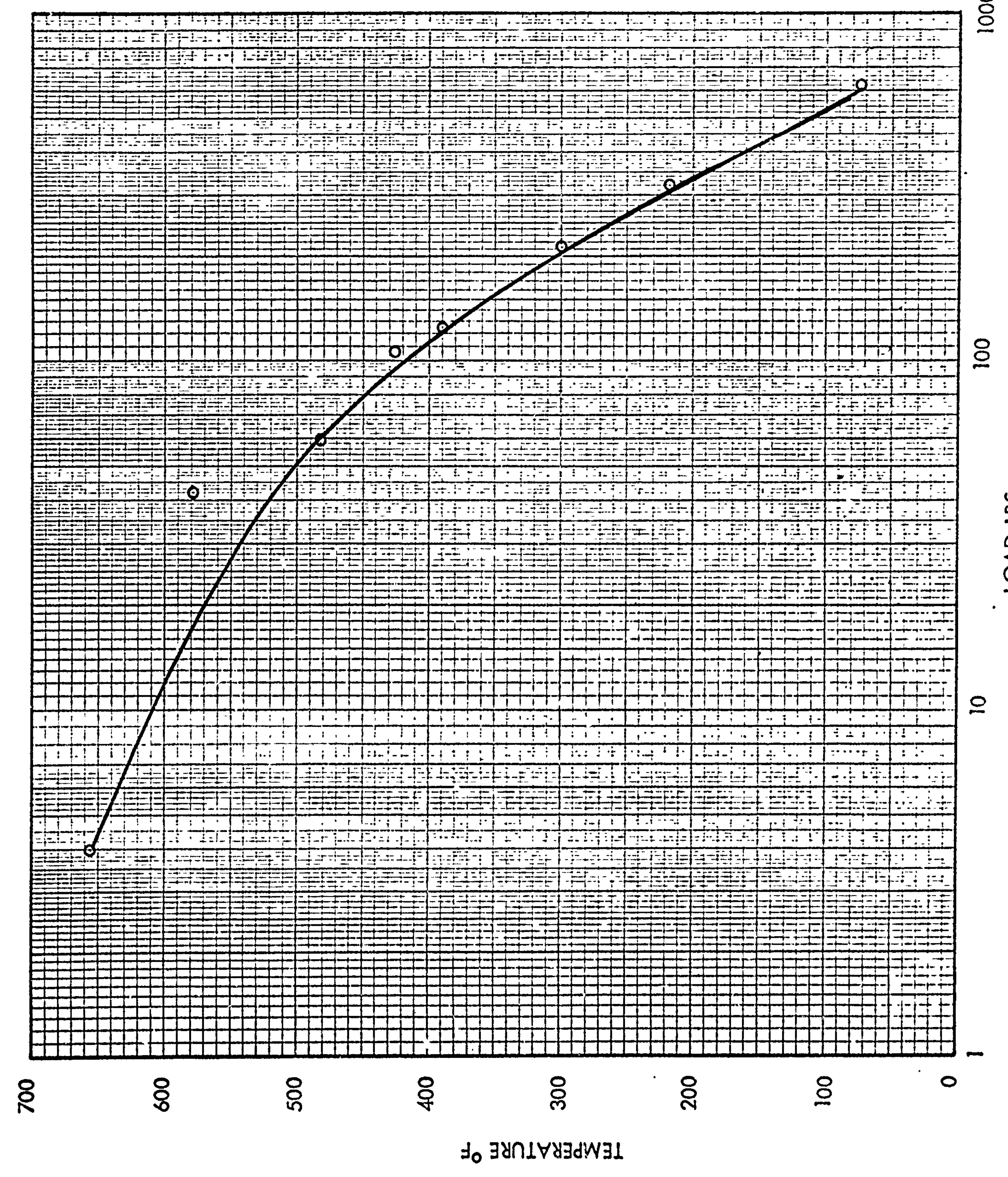


Figure 49. Test Number 5

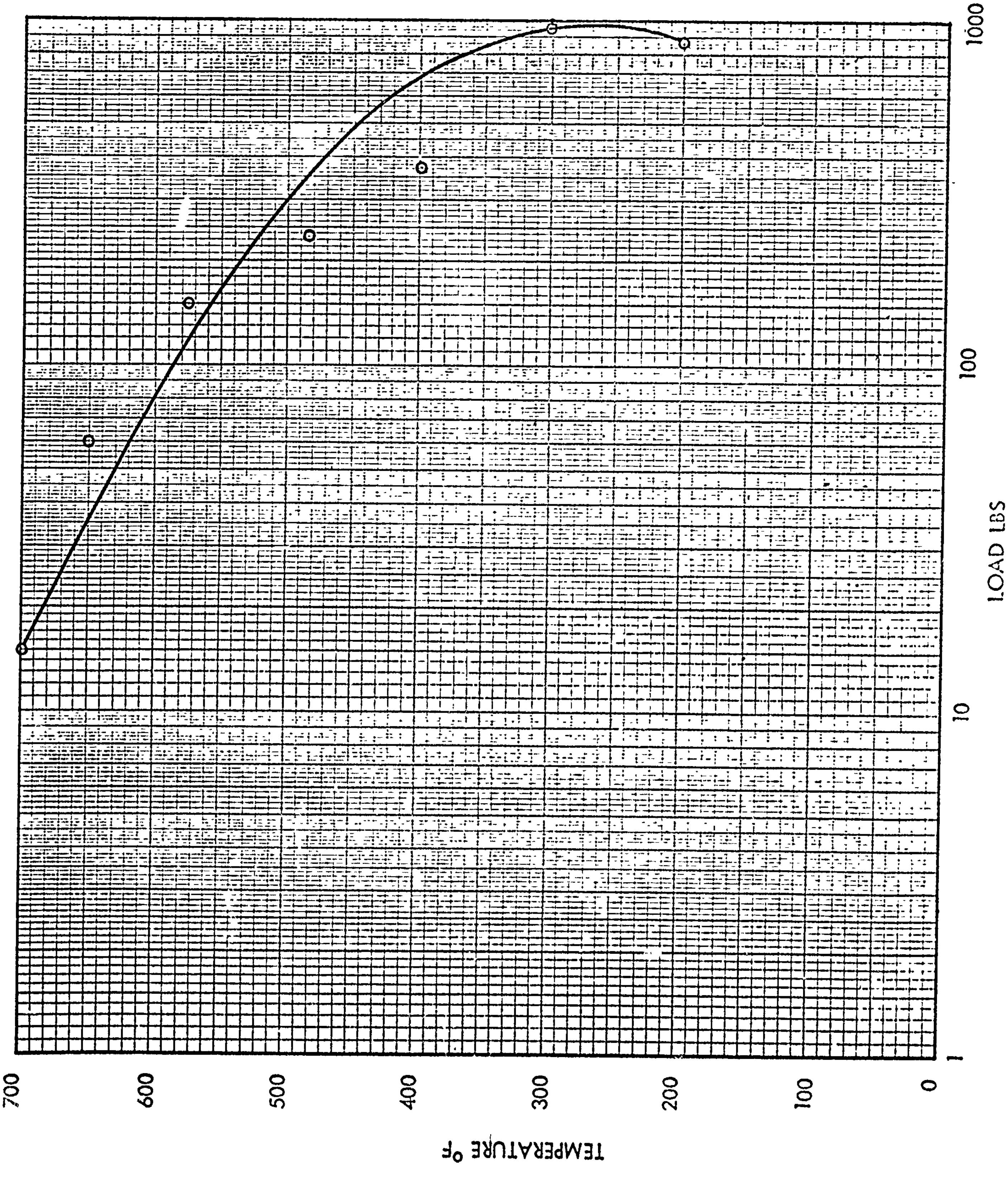


Figure 50. Test Number 6

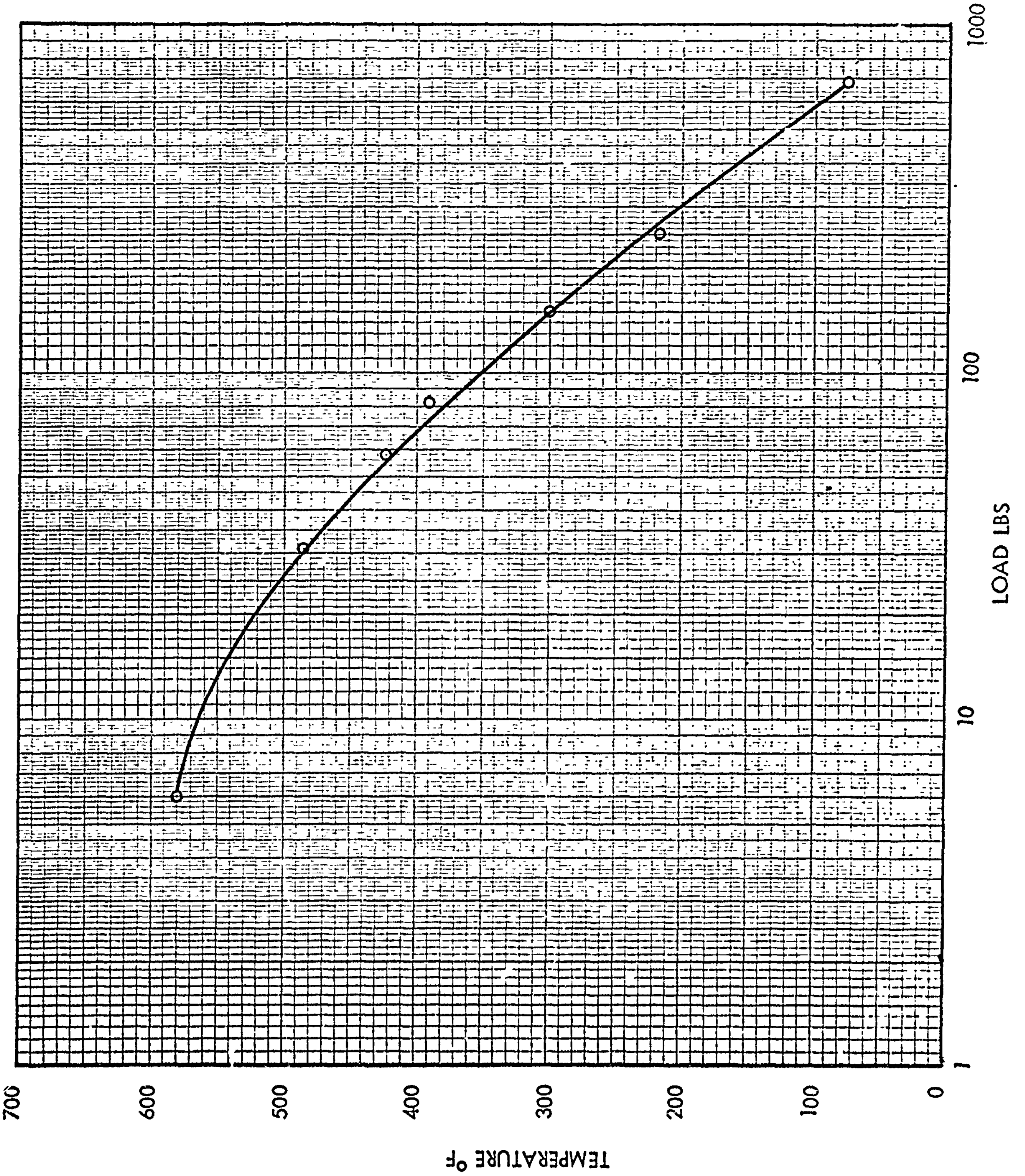


Figure 51. Test Number 7

2.14 Thermal Shock Test No. 1

2.14.1 General

2.14.1.1 The purpose of this test was to investigate the response of Apollo Operational Beacon Antenna models to thermal shock, as required by paragraphs 4.5.8 through 4.5.8.5 of NAA/S&ID Specification MC 481-0005, Revision C, and to determine the suitability, for final antenna qualification tests, of the testing techniques used.

2.14.1.2 Four identical models were tested under conditions approximating those defined in the above reference. Thermocouples embedded in the models were used to measure the temperature rise with time during and after the run.

2.14.1.3 A calorimeter model was also tested to calibrate the tunnel operating conditions in terms of heat flux to the antenna window.

2.14.2 Description of Test Facility

2.14.2.1 The Hyperthermal Electric Arc Facility is an essentially continuous-running wind tunnel which produces subsonic to Mach 3 gas flows at very high temperatures. The flow is produced by passing any of several gases, such as nitrogen, argon, or helium, through a high-current d.c. electric arc, and exhausting the resultant plasma through either a Mach 3 contoured nozzle, or a sonic orifice, to impinge on the test model of specimen.

2.14.2.2 In Figure 52, the arc-head, and nozzle assemblies are at the right, and a heat exchanger, for cooling the gas after it leaves the test chamber, is at the left. As shown in Figure 53, provision is made for injecting a secondary gas downstream of the arc. By using

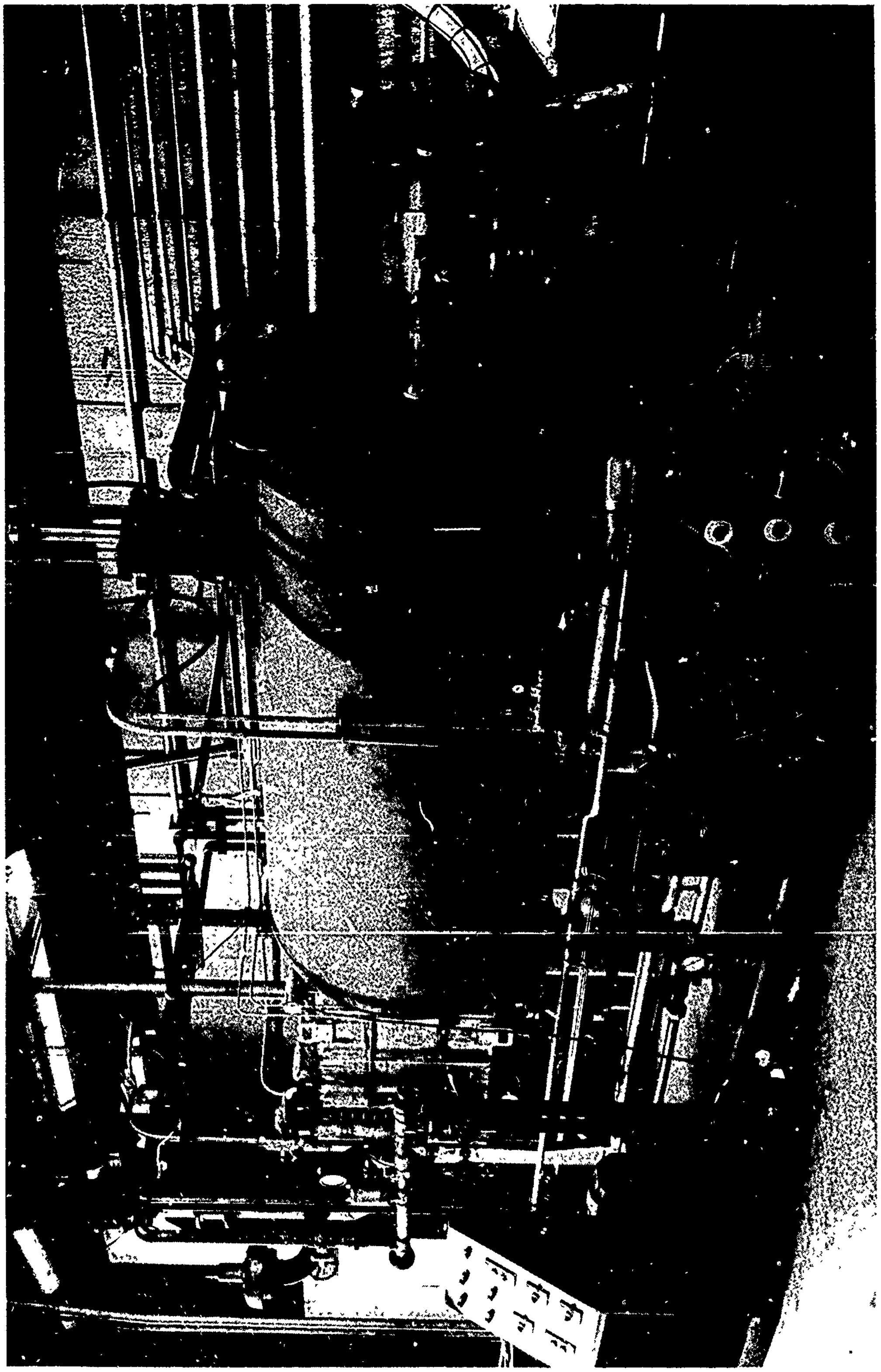


Figure 52. Overall View of Hyperthermal Electric Arc Tunnel

DO NOT MICROFILM

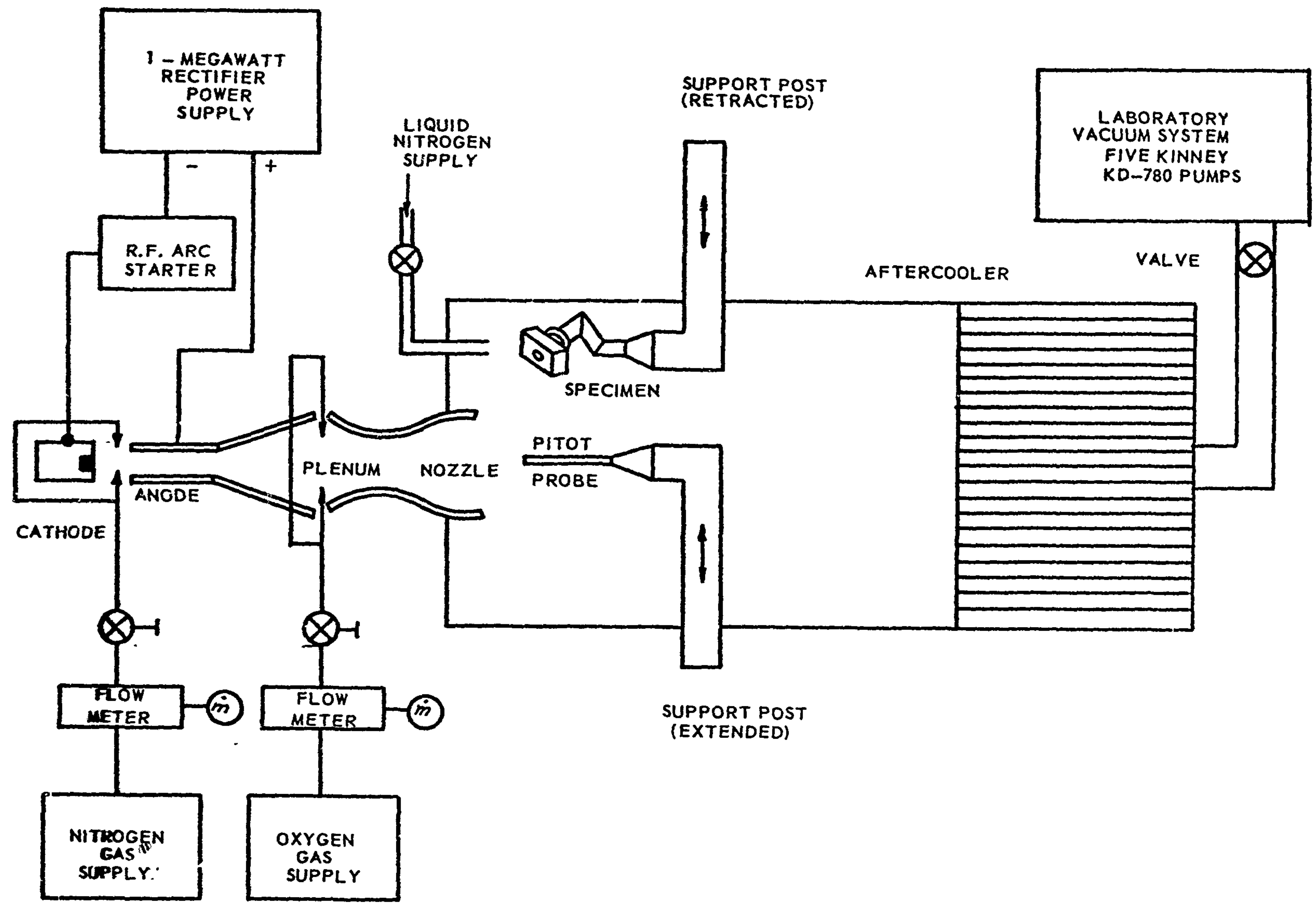


Figure 53. Simplified Schematic of Hyperthermal Electric Arc Facility

nitrogen as the primary gas, then post-injecting oxygen in the proper proportion, air may be reconstituted for use as the test medium, while the electrode erosion which would be produced by passing oxygen through the arc is avoided.

2.14.2.3 The power supply is capable of delivering one megawatt of d.c. power for periods up to one hour, with higher power available for reduced run time.

2.14.2.4 Specimens and flow survey, instrumentation are mounted on two hydraulically retracted, water-cooled support posts. The upper post can be seen on top of the test chamber in Figure 52.

2.14.3 <u>Antenna Models</u>

2.14.3.1 Each model consisted of a sintered quartz rod, one inch in diameter. One end of the rod was held by a graphite clamp in an aluminum flange. The other end, which represented the exposed "window" of the antenna, was surrounded by ablative material similar to that used in the Apollo heat shield. See Figure 54.

2.14.3.2 The only differences between the models and the production antennas were that the production antennas will extend beyond the clamp assembly and terminate in a cap which provides for connection to the associated circuitry, and that the models each contained four thermocouples, three embedded in the quartz rod and one attached to the graphite clamp.

2.14.4 <u>Calorimeter Model</u>

2.14.4.1 In order to determine the heat flux to the antenna window under various tunnel operating conditions, a calorimeter model was used which replaced the quartz rod with a copper slug, one inch in

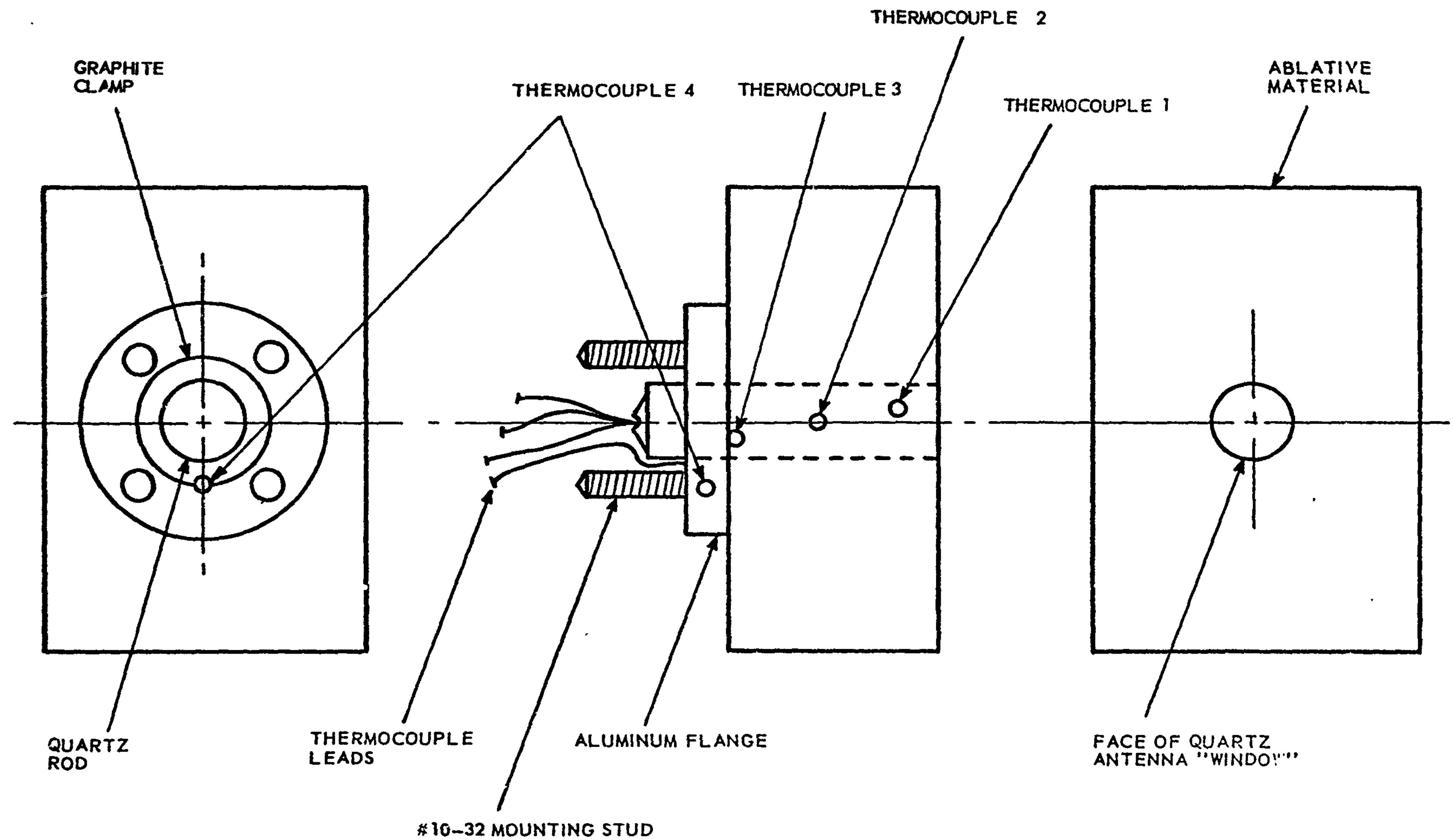


Figure 54. Sketch of Antenna Model

diameter and 0.30 inches thick. The ablation material around the antenna was replaced by a phenolic-quartz cloth laminate which resisted ablation well enough to permit measurements to be made of the temperature rise of the copper slug by means of a thermocouple embedded in it. The calorimeter model was held in the same position in the test chamber as the antenna models.

2.14.5 Test Procedures

2.14.5.1 Installation

2.14.5.1.1 Each model was attached by means of its flange bolts to an aluminum adapter, which was supported in turn by a water-cooled sting. The plane of the antenna window face was held at 30° to the direction of flow, with the center of the quartz rod end coinciding with the tunnel centerline. The model and adapter were then rotated about the tunnel centerline to a position permitting the face of the model to be photographed by a motion picture camera. Figure 55 shows the model mounted in test position as viewed from the back. Figure 56 is the view through the camera window.

2.14.5.1.2 All thermocouples were chromel-alumel and had an ice-bath reference junction. The outputs were recorded on self-balancing potentiometer strip-chart recorders.

2.14.5.2 Operation

2.14.5.2.1 Since the desired variation in heat flux vs. time as given in MC 481-0005, Revision C could not be followed exactly by the tunnel, an approximate variation of each condition was determined which would give the same total heat load as the specified trajectory, and would approach the most severe peak heating rate for each

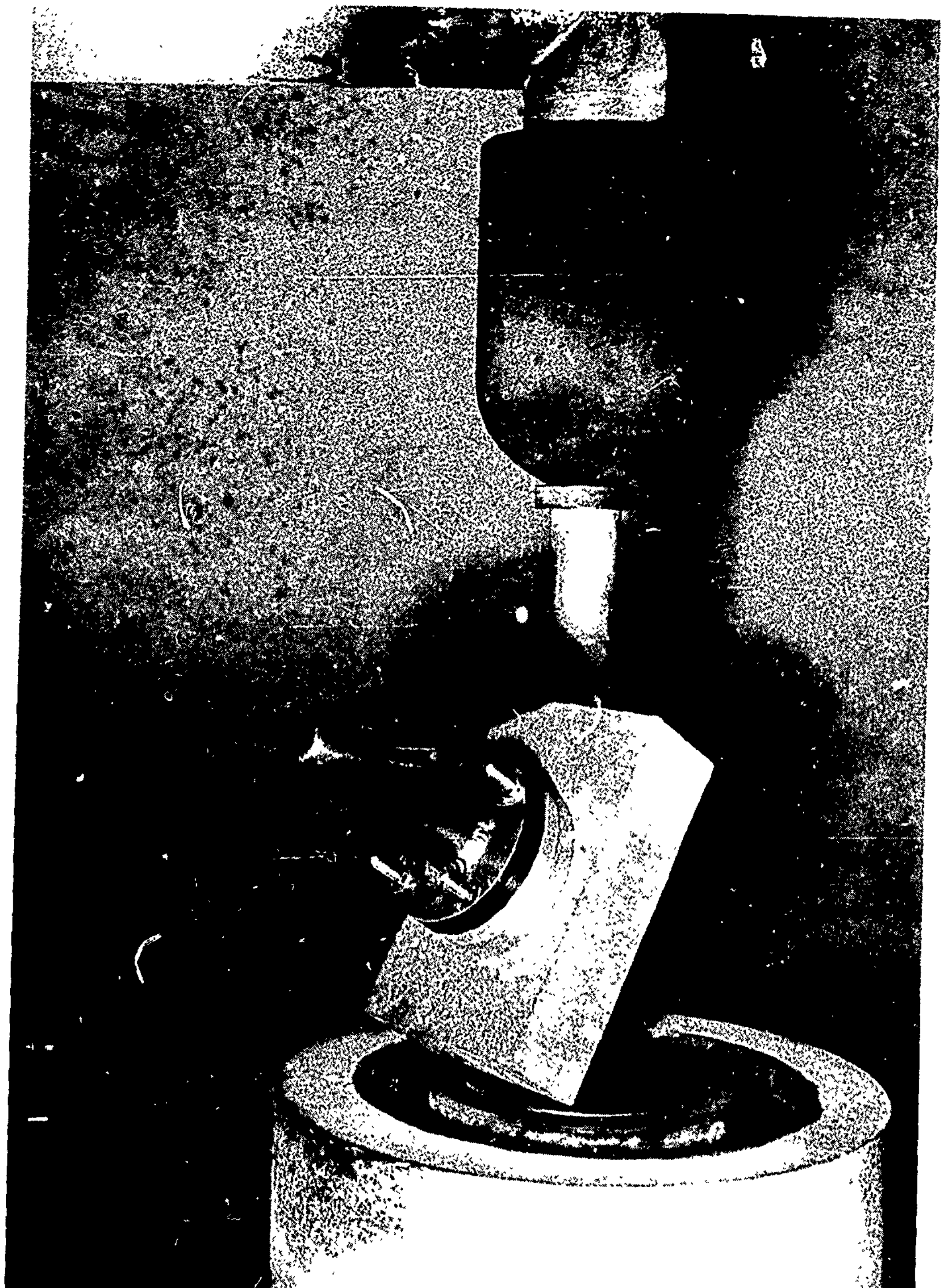


Figure 55. Model and Holder in Test Position - Rear View

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Figure 56. Model and Holder in Test Position - Front View

condition. The conditions were controlled by manually varying the power input to the tunnel while maintaining a constant gas flow. Deviations from ideal power variation caused the actual heat flux history to vary from that planned. Figures 57, 58, 59 and 60 compare the desired variation in heat flux with that actually achieved, and present the time history of stagnation enthalpy for each run.

2.14.5.2.2 The test requirement called for heating two of the specimens to 250°F before inserting into the flow, and cooling the other two specimens to -150°F before insertion. The heating was accomplished by allowing the specimen to remain in the retracted position for several minutes, while the tunnel was operated at high power. Convection of the hot gas inside the test chamber accomplished the heating. The heating period was terminated when one of the four thermocouples indicated 250°F, under the conservative assumption that the surface of the specimen was at least that value. The tunnel power was then adjusted to the desired value, and the specimen inserted into the stream. It was noted that the specimen temperature dropped somewhat during the power adjustment period (to a minimum of 235°F), but since it had been at 250°F or higher, the requirement was considered to have been met.

2.14.5.2.3 In order to cool the remaining two specimens to -150°F as required, a nozzle for spraying liquid nitrogen (-320°F) on the face of the model was used. The calorimeter meter was installed and the termocouple recorder polarity reversed in order to read temperatures below the reference junction temperature of 32°F. Liquid nitrogen was then sprayed on the calorimeter until the thermocouple read -150°F and the time required to reach this point noted. Then, when the

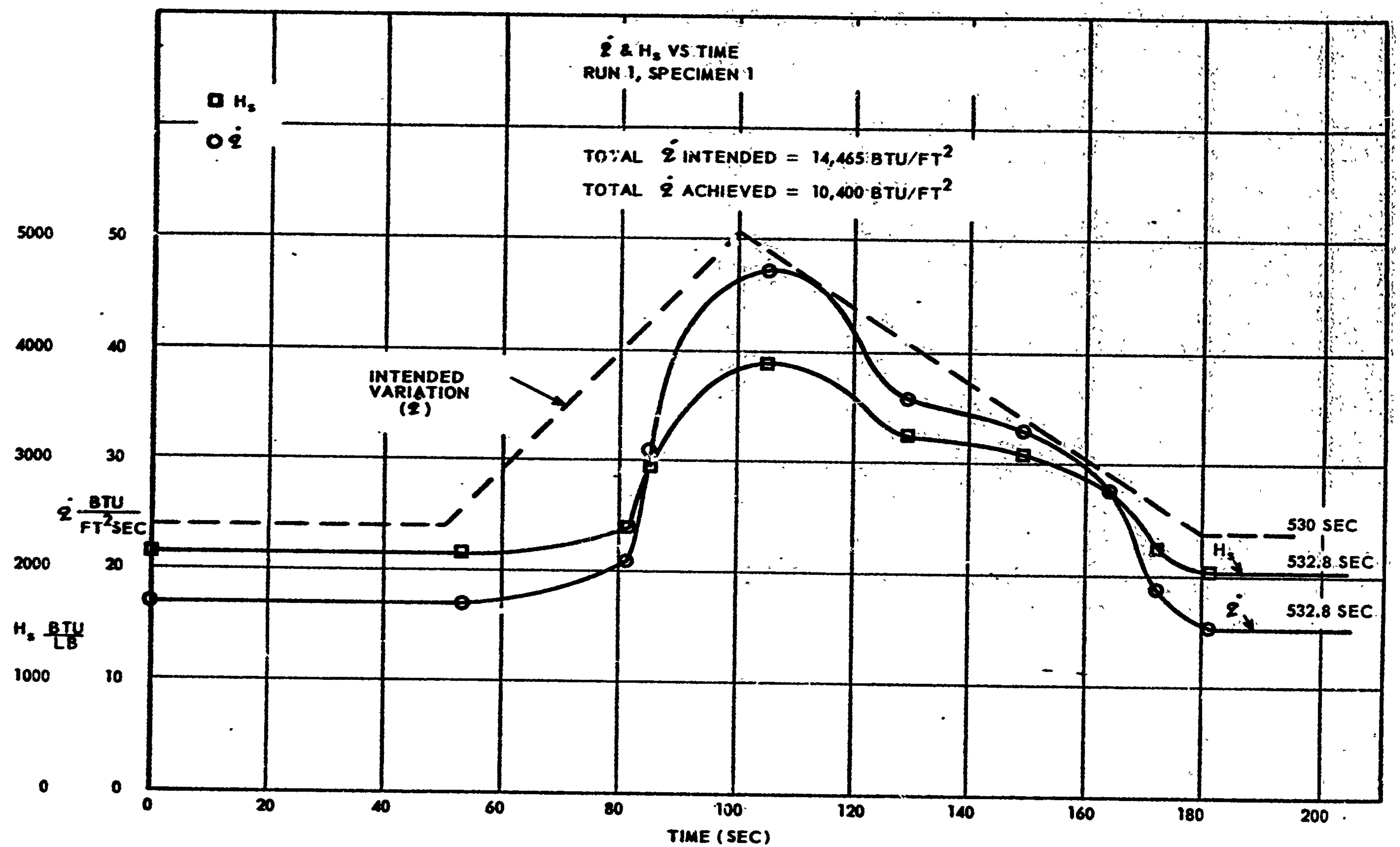

Figure 57. Run 1, Specimen 1

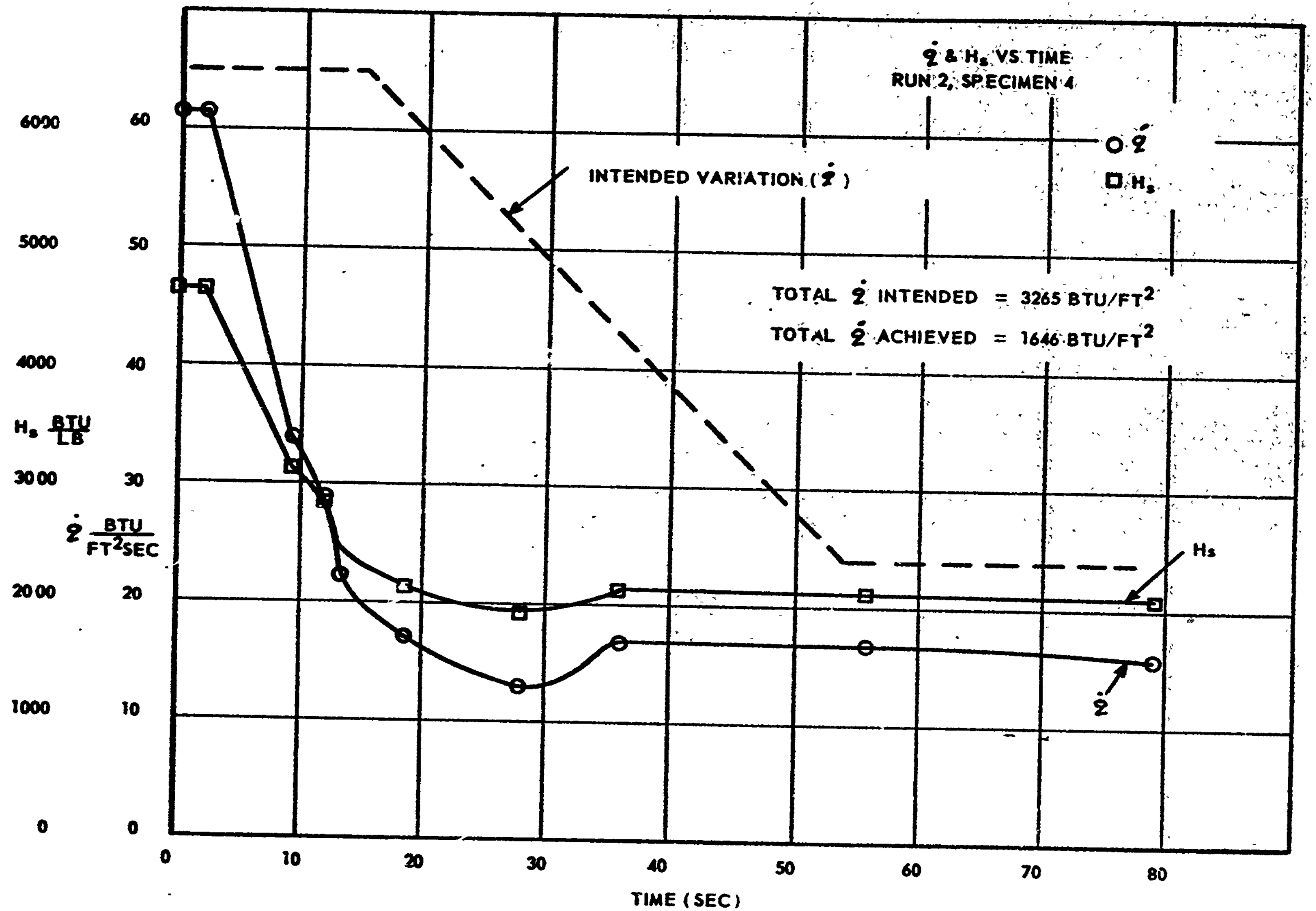

Figure 58. Run 2, Specimen 4

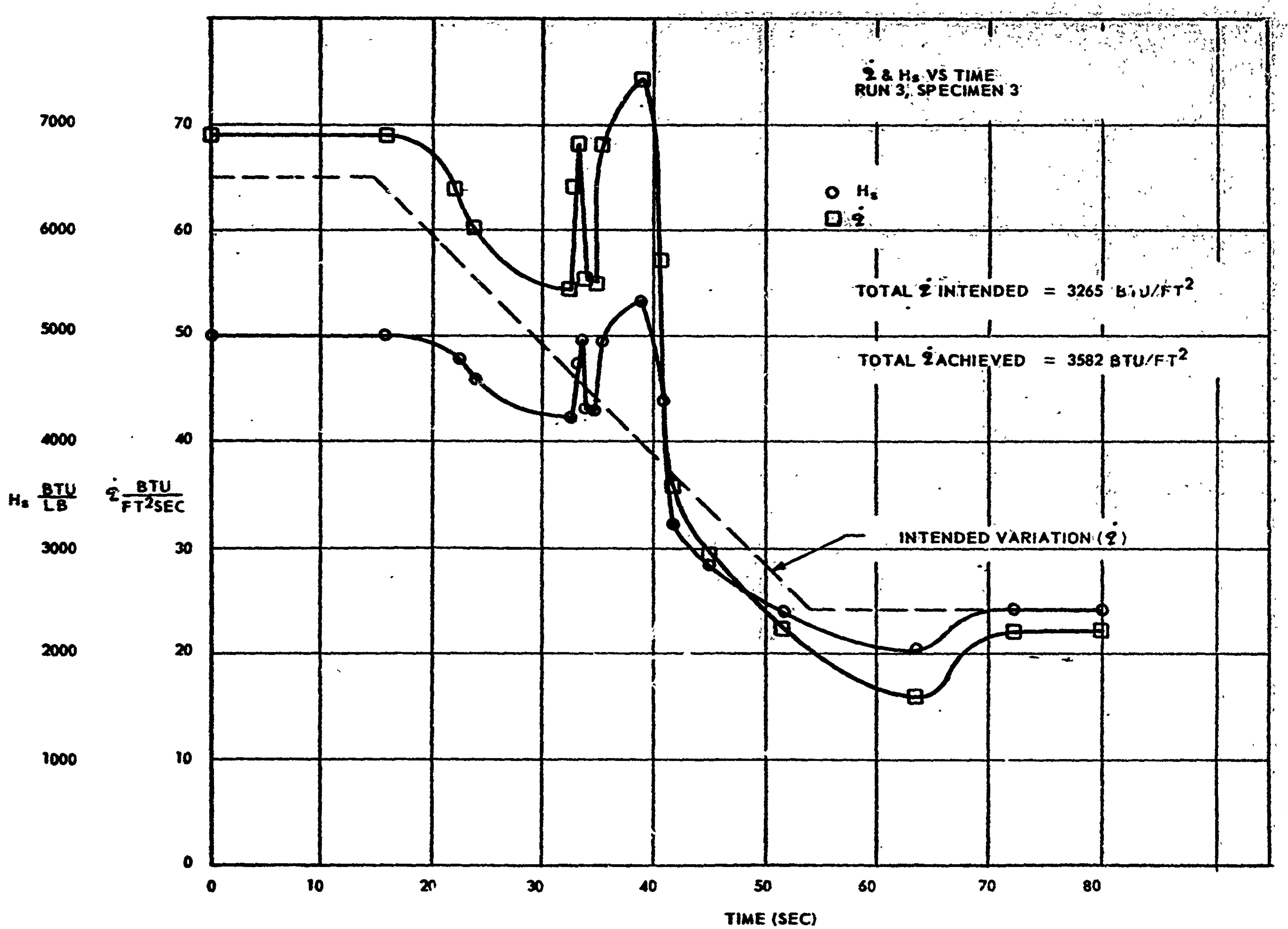

Figure 59. Run 3, Specimen 3

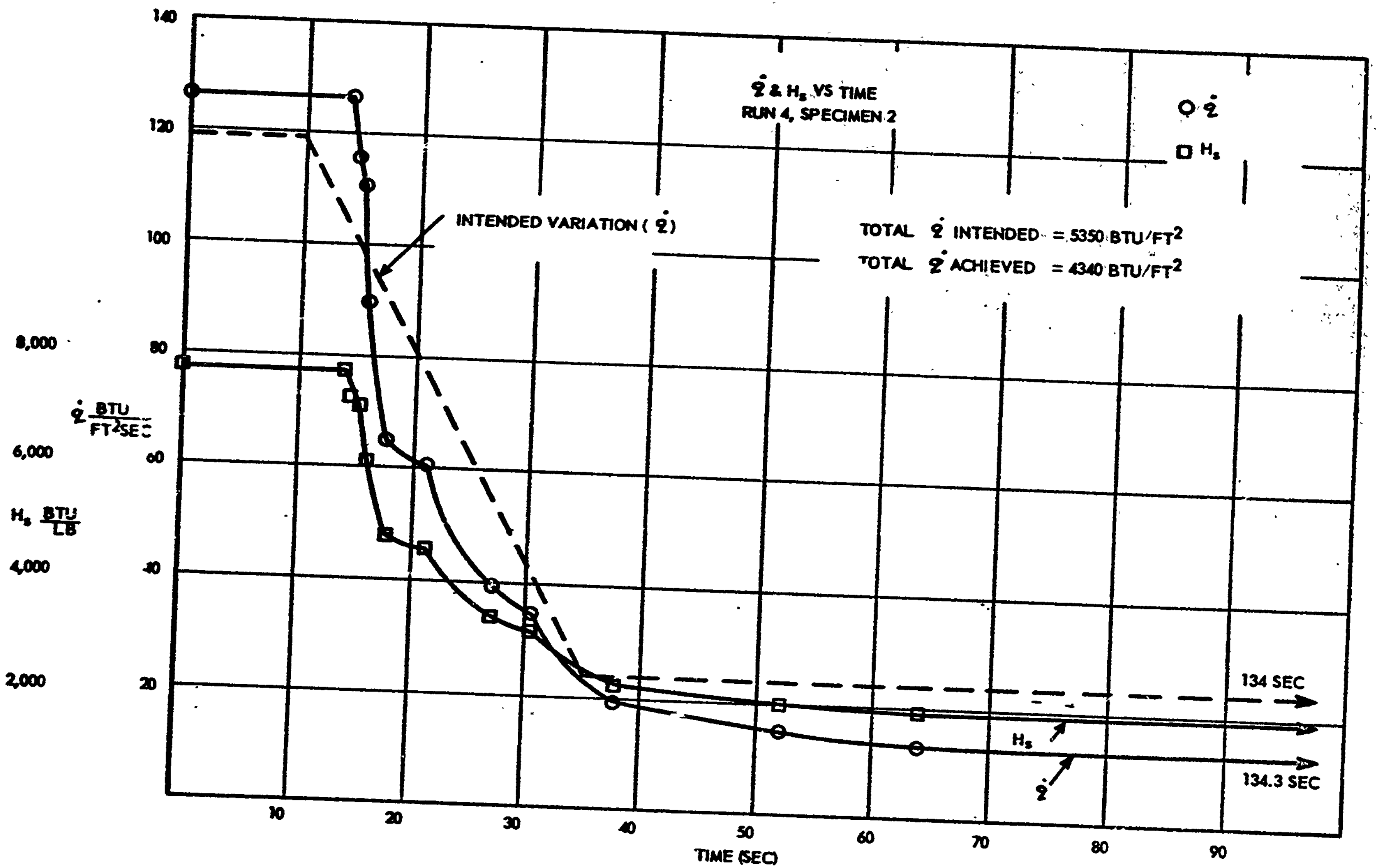

Figure 60. Run 4, Specimen 2

antenna model was installed, it was sprayed with liquid nitrogen for twice this length of time, with the assumption that the surface would reach -150°F or colder, satisfying the test requirement. Motion pictures of the tests showed that nitrogen "snow" was present on the face of the model as it entered the flow, indicating an extremely low surface temperature. Temperatures below 32°F could not be recorded during a test run, so thermocouple #1 was off scale for the initial portion of runs 3 and 4.

2.14.5.3 Calibrations

2.14.5.3.1 Test runs with the calorimeter model were performed at constant mass flow, and various fixed levels of power. For each run, the heat-flux to the calorimeter, and the stagnation enthalpy were computed, and the plenum pressure upstream of the Mach 3 nozzle was recorded. These values were tabulated for use in reducing the data for the antenna model test runs (see paragraph 2.14.6).

2.14.6 Data Reduction

2.14.6.1 Test Nomenclature

2.14.6.1.1 In the following calculations, the below listed symbols are used:

A^*	Sonic throat area - ft.^{2}
C_c	Specific heat of copper - BTU/lb.-°F
E	Power - BTU/sec.
H_s	Stagnation Enthalpy - BTU/lb.
$\dot{m}$	Flow rate - lb./sec. or gal./min.
P_o	Plenum (isentropic stagnation) pressure - atmosphere
$\dot{q}$	Heat flux - BTU/ft.^{2} sec.
T	Temperature - °F

X	Thickness of calorimeter slug - ft.
ρ_c	Density of copper - lb./ft.^{3}
$(dT/d\tau)$	Slope of calorimeter thermocouple output - = °F/sec.

Subscripts,

AIR	Refers to gas flow through tunnel
H/B	Heat Balance method
IN	Input
OUT	Losses to cooling water
S/T	Sonic Throat method
W	Cooling water

2.14.6.2 Equations and Methods

2.14.6.2.1 Stagnation enthalpy is determined by two methods, a heat balance calculation and the "sonic-throat" method.

$$H_s, H/B = \frac{E_{IN} - E_{OUT}}{\dot{m}_{AIR}} \quad \text{BTU/LB}$$

where: $E_{IN} = 0.948$ (Volts x Amperes) x 10^{-3} BTU/SEC

$$E_{OUT} = 0.1388 \, (\dot{m}_W) \, (\Delta T_W) \quad \text{BTU/SEC}$$

$\dot{m}_W$ and ΔT_W are, respectively, the flow rate and temperature rise of the water cooling the cathode and anode of the arc heater.

$$H_s, S/T = f\left(\frac{\dot{m}_{AIR}}{P_o A^*}\right), \quad \text{BTU/LB}$$

The function is plotted in "Charts for Equilibrium Flow Properties of Air in Hypervelocity Nozzles", by Jorgensen, L. H., and Baum, G. M., (NASA TN D-1333. September 1962) which can be used directly.

2.14.6.2.2 The average of H_s, H/B and H_s, S/T is considered the best value of H_s to use in data analysis.

2.14.5.2.3 Heat flux to the calorimeter slug was computed by means of the one-dimensional heat flux equation, assuming the slug to be isothermal.

$$\dot{q} = \rho_c C_c \, X \left(\frac{dT}{d\tau}\right), \quad BTU/FT^2 \; SEC$$

Values for ρ_c and C_c were taken at 250°F.

$$\rho_c = 556 \; LB/FT^3$$

$$C_c = .095 \; BTU/LB \; °F$$

$$X = 0.3 \text{ in.} = .025 \text{ ft.}$$

2.14.6.2.4 For each test run, P_o was the only tunnel parameter recorded continuously. By using plots of $\dot{q}$ and H_s vs. P_o from the calibration runs, it was possible to construct the variation of $\dot{q}$ and H_s with time, as shown in Figures 57, 58, 59 and 60.

2.14.6.2.5 Thermocouple data were converted from recorder counts to °F on an IBM 7094 digital computer by means of a program which incorporates a curve-fit of thermocouple tables as given in "Reference Tables for Thermocouples", by NBS Circular 561, 1955, by Shenker, H., Lauritzen, J. I. Jr., Corruccini, R. J., and Lonberger, S. T.

2.14.6.2.6 The program produces plots (Figures 61, 62, 63 and 64) and of temperature vs. time which identify each thermocouple by numbers directly on each curve. Thermocouples 1 through 4 correspond to the original designations of A, B, C, and D.

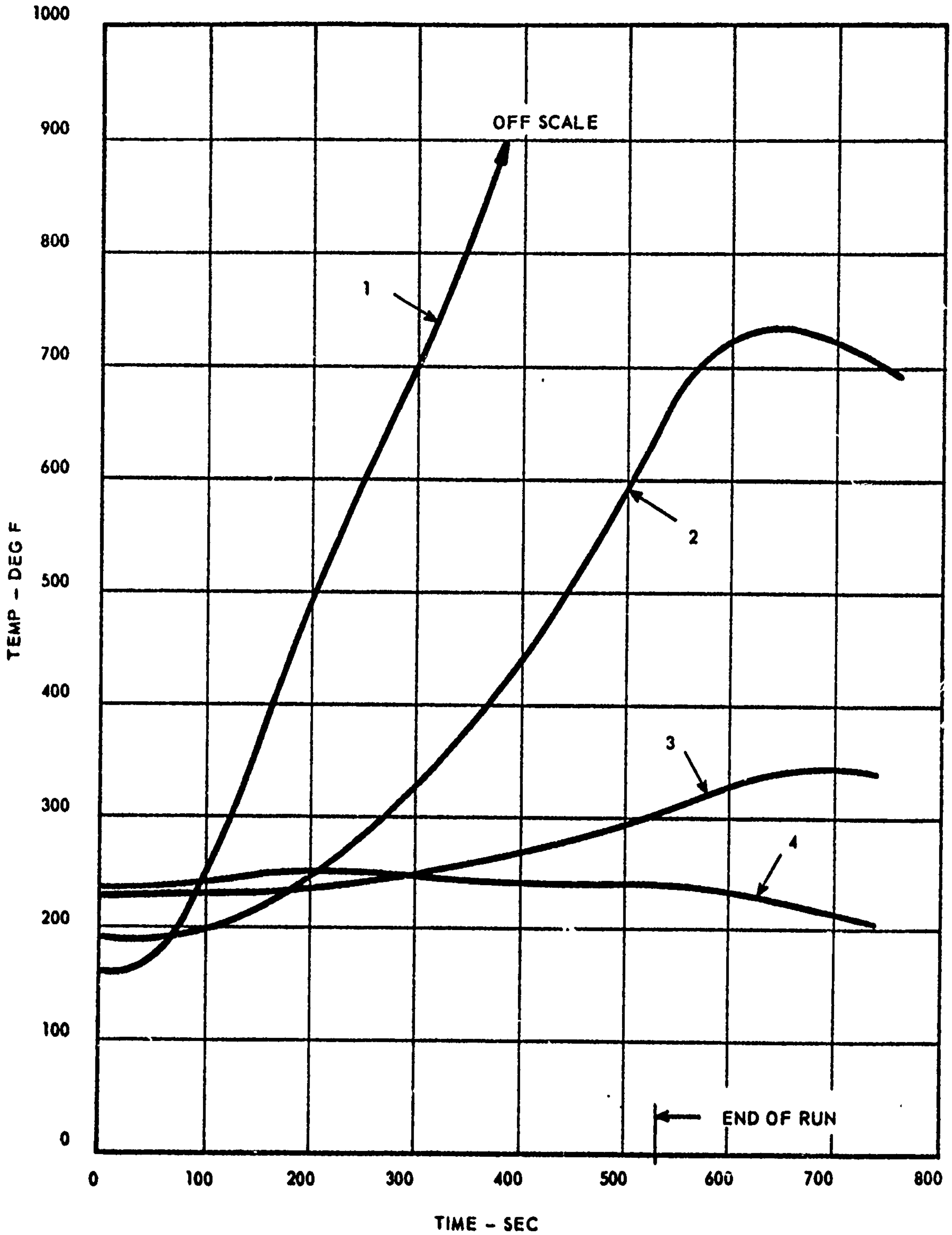

Figure 61. Run 1.0 Thermocouples 1 Through 4

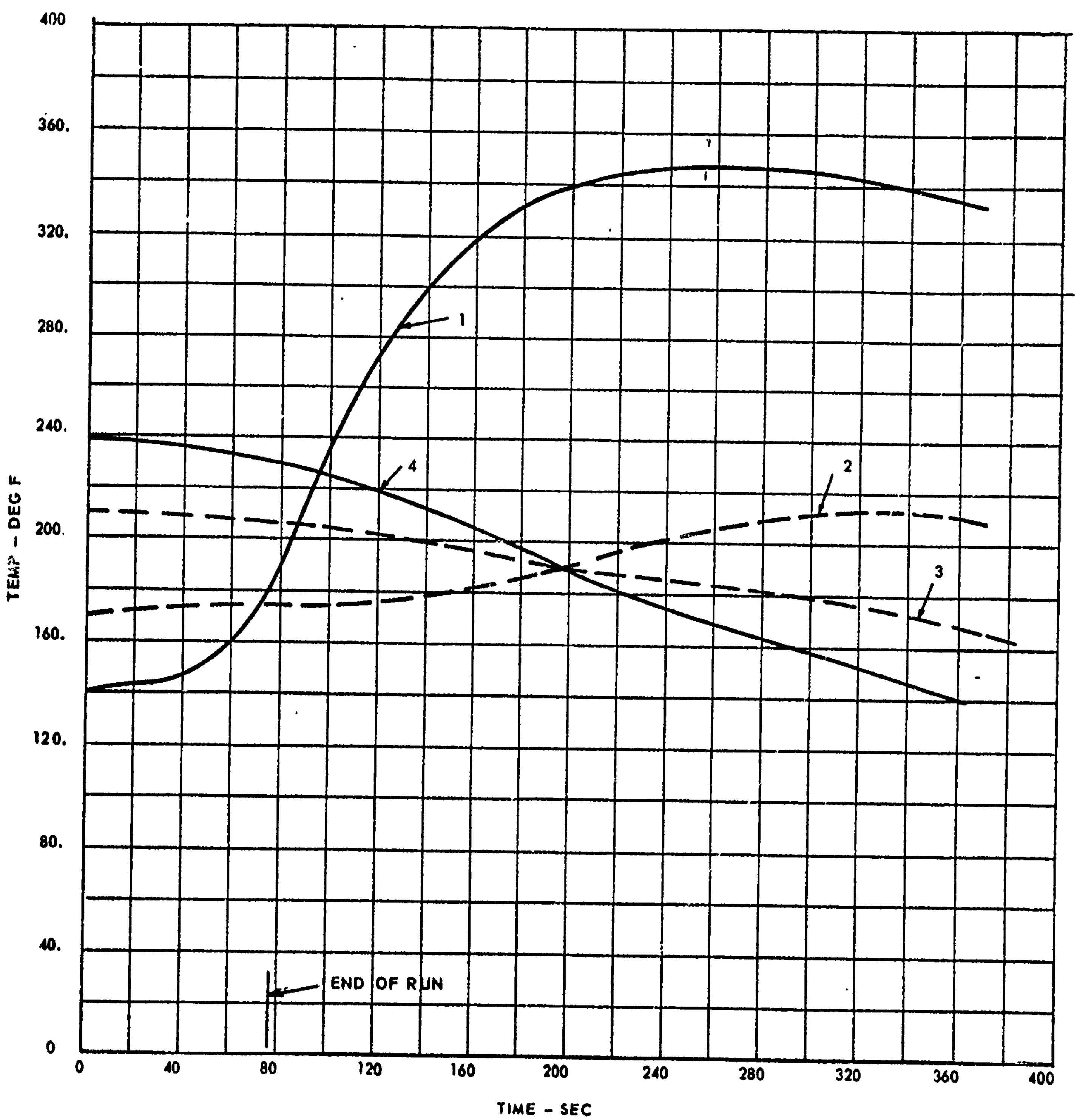

Figure 62. Run 2.0 Thermocouples 1 Through 4

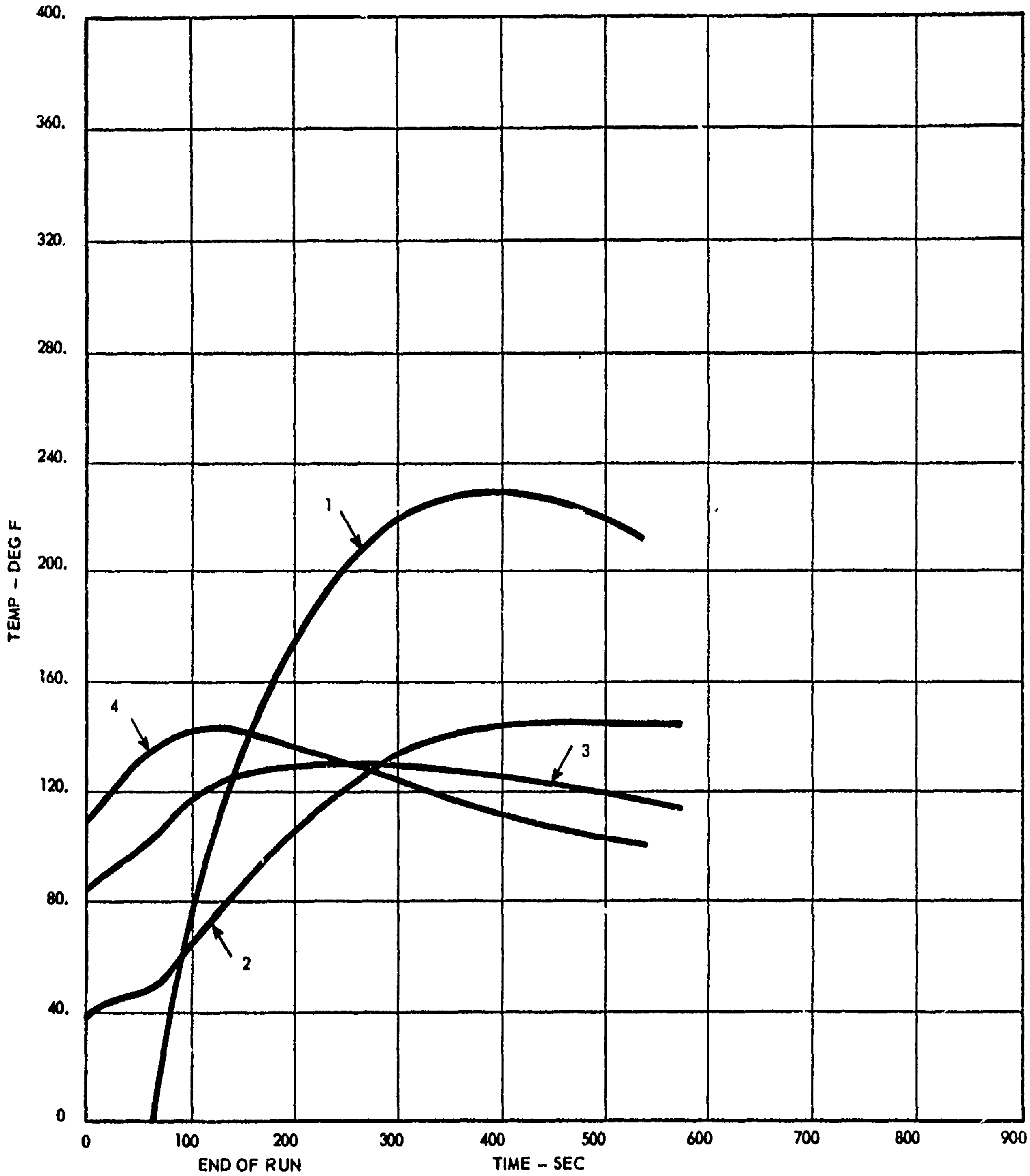

Figure 63. Run 3.0 Thermocouples 1 Through 4

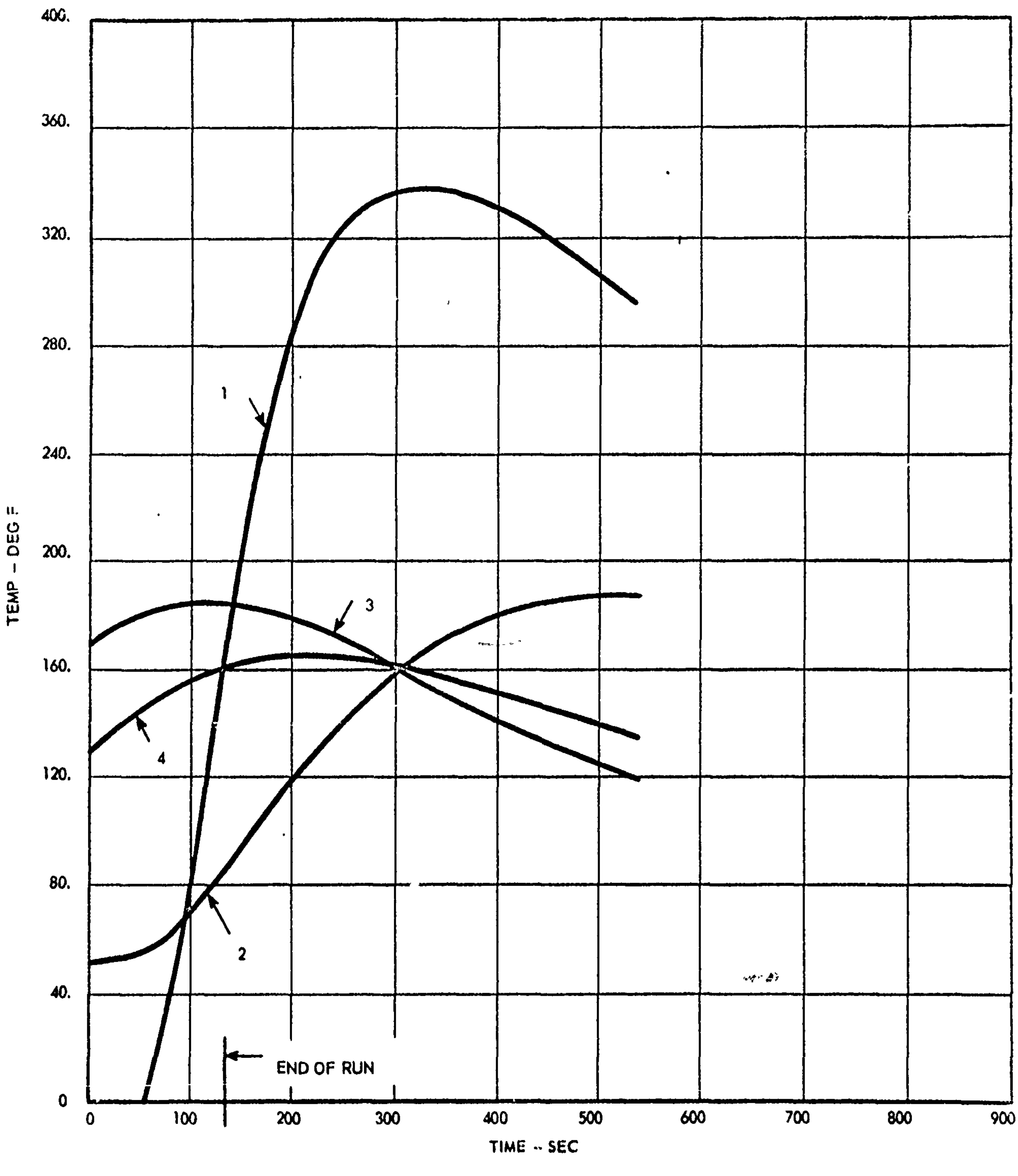

Figure 64. Run 4.0 Thermocouples 1 Through 4

2.14.7 Index of Data

2.14.7.1 Photographs and Tables of Results

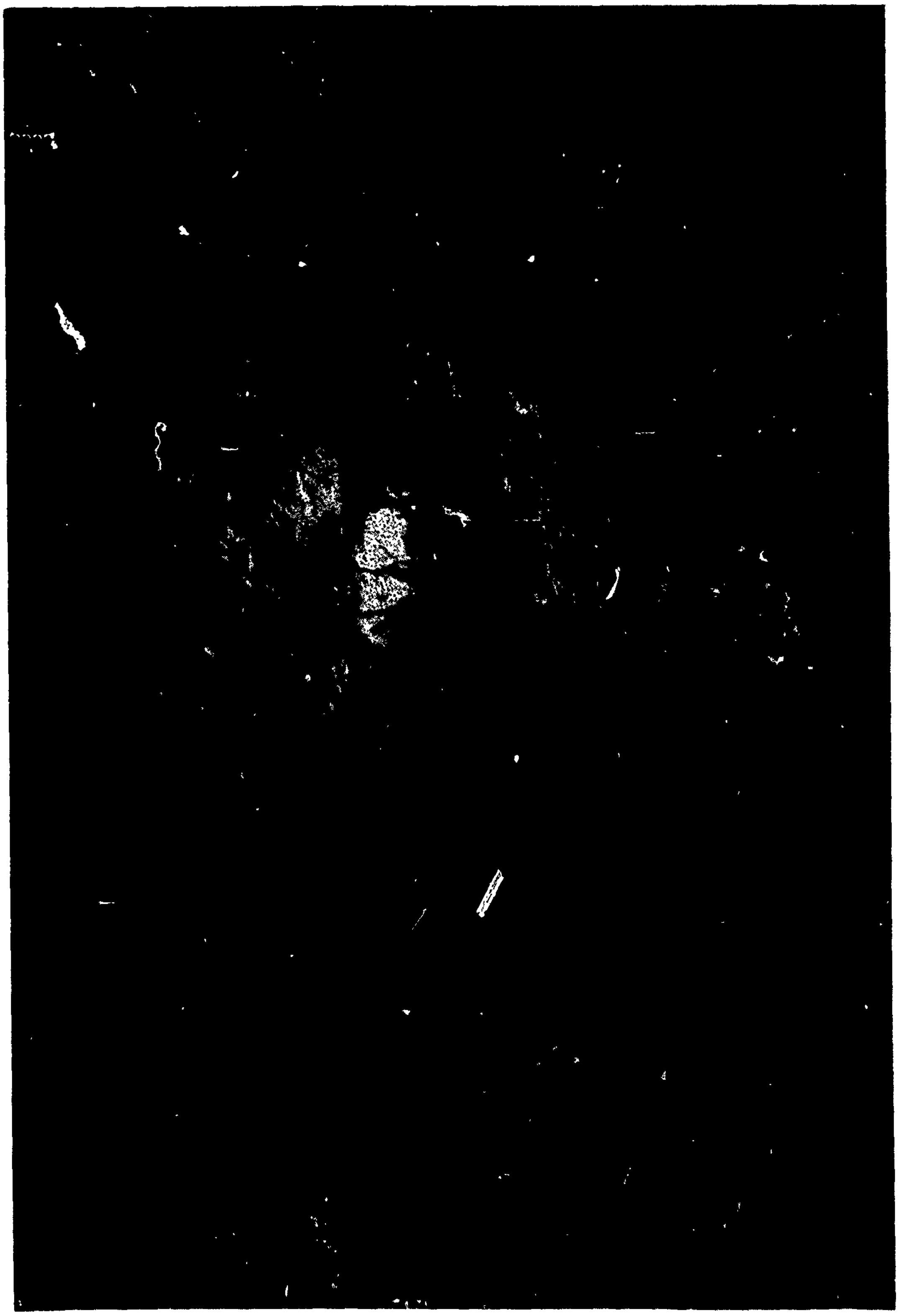

Figure 65. Run 1 - Specimen 1

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TABLE 5

TEMPERATURE-TIME HISTORY

RUN 1

	TC 1		TC 2		TC 3		TC 4	
PT.	Time Sec.	Temp Deg. F	Time Sec.	Temp Deg. F	Time Sec.	Temp Deg. F	Time Sec.	Temp Deg. F
1	0.	160	0.	190	0.	229	0.	235
2	41.96	166	121.92	199	63.23	225	42.45	235
3	71.94	193	201.87	246	94.01	225	96.09	238
4	101.91	246	308.47	336	149.42	226	157.40	248
5	203.82	508	395.09	430	217.15	236	188.05	250
6	251.77	612	441.72	500	284.87	248	272.34	246
7	317.71	740	508.35	606	352.59	259	356.63	242
8	371.67	871	532.80	645	420.32	272	440.92	239
9	532.80	31	532.87	662	488.04	289	502.23	241
10	-0.	31	554.99	692	532.80	304	532.80	242
11	-0.	31	574.97	711	531.20	306	532.88	243
12	-0.	31	601.62	727	580.39	325	563.53	241
13	-0.	31	634.94	730	617.33	336	632.49	227
14	-0.	31	681.57	727	672.74	344	678.47	218
15	-0.	31	721.55	713	703.53	344	735.1[illegible]	207
16	-0.	31	752.13	696	737.82	341	-0.	31

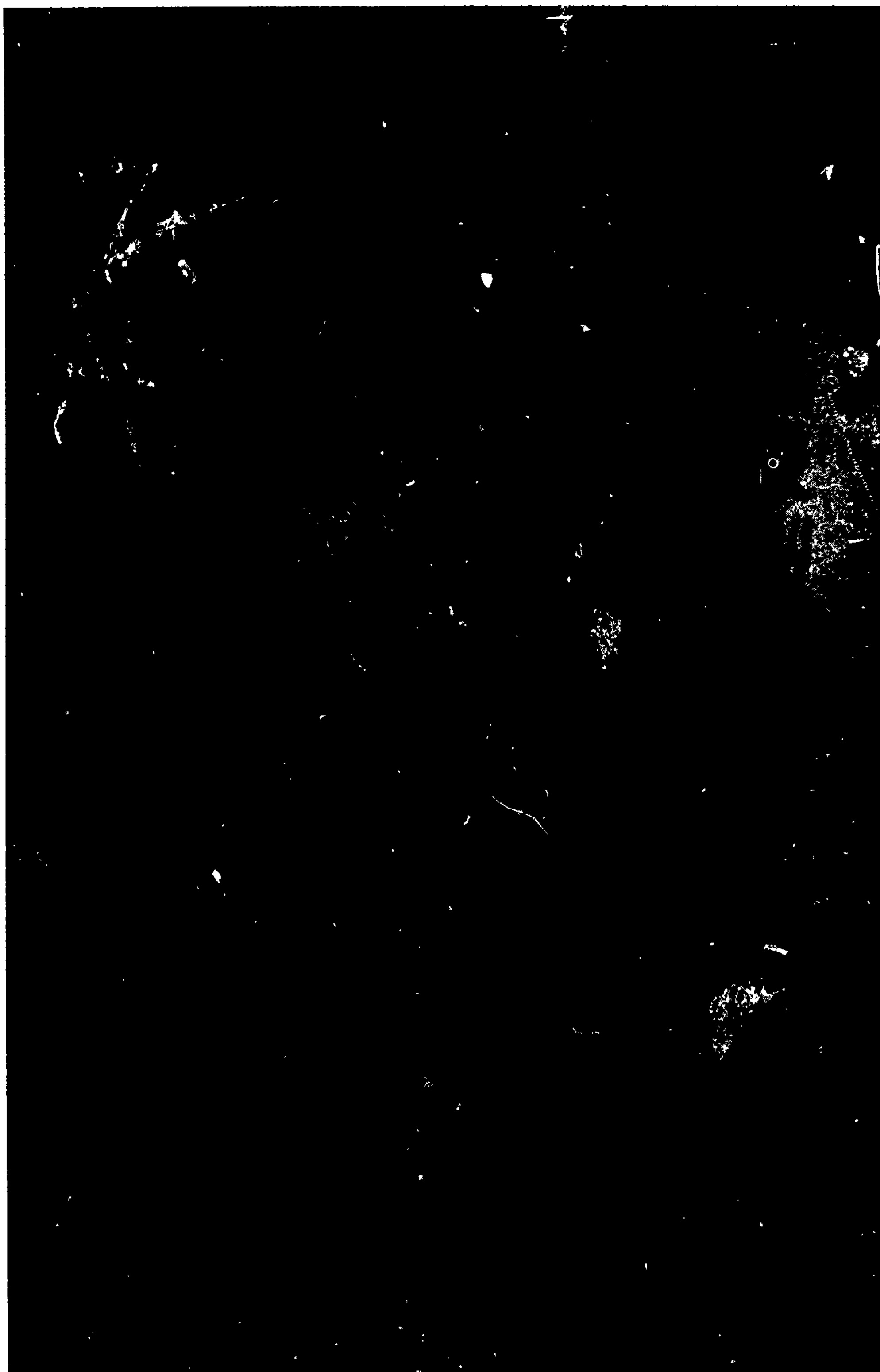

Figure 66. Run 2 - Specimen 4

TABLE 6

TEMPERATURE-TIME HISTORY

RUN 2

	TC 1		TC 2		TC 3		TC 4	
PT.	Time Sec	Temp Deg. F	Time Sec.	Temp Deg. F	Time Sec.	Temp. Deg. F	Time Sec.	Temp. Deg. F
1	0.	141	0.	169	0.	210	0.	238
2	18.00	143	2.30	171	70.75	207	30.83	236
3	35.99	147	79.00	173	79.00	206	79.00	231
4	47.99	143	79.07	176	79.06	204	79.08	230
5	59.98	162	146.17	182	115.53	203	107.53	224
6	71.98	177	222.73	199	147.51	200	138.21	214
7	79.00	189	285.37	209	198.68	193	191.90	191
8	79.06	197	348.02	212	262.65	182	268.60	166
9	107.97	252	371.33	211	320.22	173	314.62	151
10	125.97	282	-0.	31	352.21	168	362.86	140
11	143.96	305	-0.	31	383.36	162	-0.	31
12	161.96	322	-0.	31	-0.	31	-0.	31
13	179.95	333	-0.	31	-0.	31	-0.	31
14	215.95	344	-0.	31	-0.	31	-0.	31
15	269.93	348	-0.	31	-0.	31	-0.	31
16	311.92	344	-0.	31	-0.	31	-0.	31
17	364.47	333	-0.	31	-0.	31	-0.	31

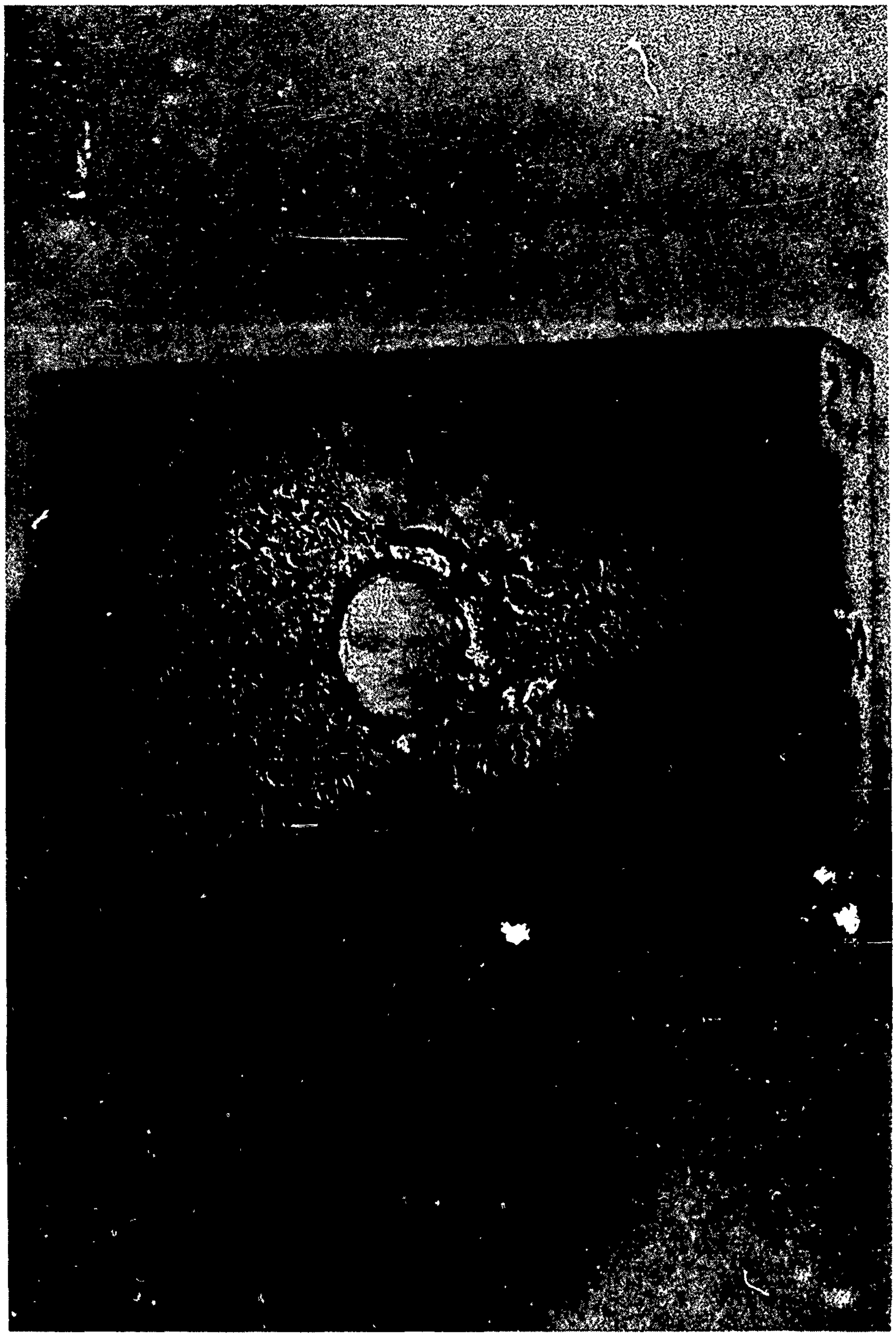

Figure 67. Run 3 - Specimen 3

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TABLE 7

TEMPERATURE-TIME HISTORY

RUN 3

	TC 1		TC 2		TC 3		TC 4	
PT.	Time Sec.	Temp Deg. F	Time Sec.	Temp Deg. F.	Time Sec.	Temp Deg. F	Time Sec.	Temp Deg. F
1	0.	31	0.	31	0.	84	0.	108
2	80.00	31	1.41	39	20.44	90	3.11	110
3	80.06	38	21.16	43	33.93	93	16.02	115
4	83.60	46	63.49	48	80.00	108	39.34	127
5	95.59	64	80.00	52	80.07	114	54.89	132
6	131.57	112	80.07	57	121.62	122	62.66	134
7	161.56	146	148.15	84	168.84	127	80.00	138
8	191.54	173	211.64	111	202.56	129	80.08	141
9	221.53	193	289.24	131	256.53	130	93.76	142
10	269.51	212	366.84	142	330.73	128	140.41	141
11	305.49	221	437.39	144	404.92	124	202.60	135
12	341.47	225	535.24	144	472.38	121	295.90	123
13	449.42	225	-0.	31	546.58	115	389.19	112
14	520.54	216	-0.	31	572.01	113	474.71	104
15	-0.	31	-0.	31	-0.	31	528.67	100

Figure 68. Run 4 - Specimen 2

DO NOT MICROFILM

TABLE 8

TEMPERATURE-TIME HISTORY

RUN 4

PT.	TC 1 Time Sec.	TC 1 Temp. Deg. F.	TC 2 Time Sec.	TC 2 Temp. Deg. F	TC 3 Time Sec.	TC 3 Temp. Deg. F	TC 4 Time Sec.	TC 4 Temp. Deg. F
1	0.	31	0.	47	0.	168	0.	129
2	76.88	31	13.96	52	36.95	178	7.86	132
3	113.82	117	41.88	53	61.50	182	30.99	138
4	125.83	145	104.70	71	79.92	183	69.54	150
5	134.30	162	134.30	81	134.30	183	92.67	155
6	134.36	170	134.37	90	134.36	183	123.51	159
7	155.86	216	160.55	98	159.71	182	134.30	160
8	173.88	253	223.37	130	208.82	176	134.38	161
9	191.90	282	293.17	156	276.38	163	208.31	164
10	209.92	302	335.05	169	337.71	150	246.86	164
11	227.94	309	411.83	183	405.23	138	324.11	158
12	251.96	328	488.62	187	472.75	128	408.91	149
13	269.98	333	555.77	187	543.58	118	493.56	140
14	288.00	336	-0.	31	-0.	31	538.90	134
15	360.08	336	-0.	31	-0.	31	-0.	31
16	414.13	327	-0.	31	-0.	31	-0.	31
17	480.20	310	-0.	31	-0.	31	-0.	31
18	534.14	297	-0.	31	-0.	31	-0.	31

2.14.8 Test Results

2.14.8.1 With the exception of the first run, all tests were reasonably representative of the environmental parameters.

2.14.8.2 Shear pressures were in excess of the acceptable limits. In run #1 the adjacent ablative material surrounding the quartz antenna window completely disintegrated (see Figure 65). The depth of the cavity in the ablator extended over one inch from the forward surface. This exposed the quartz window to the full impact of the heat to the depth of the cavity. This condition created a pocket which entrapped the heat. Had the ablator been intact a significant portion of the heat would have been carried away. The results for run #1 are judged as not representative of the contractual specifications.

2.14.8.3 The ablation material remained satisfactory for runs #2, #3 and #4 (see Figures 66, 67, and 68).

2.14.8.4 In all instances no measurable physical change to the quartz windows was noted.

2.14.8.5 The rise in temperature at the rear of the windows (back surface) were all well within the design requirements.

2.14.8.6 The results of this series of tests, would indicate that the development thermal shock requirements as specified in paragraphs 4.5.7.2 through 4.5.7.4 of MC 481-0005, Revision C, have been achieved.

2.15 Thermal Shock Test No. 2

2.15.1 General

2.15.1.1 A second series of tests, to obtain additional temperature response data and further improve test techniques, was conducted in the NAA/LA Hyperthermal Electric Arc Wind Tunnel.

2.15.1.2 Run 1 of the original series of tests, which corresponded to Test Level No. 1 of Paragraph 4.5.7.1 of NAA Spec. MC 481-0005 Revision C, showed considerable gouging of the ablative material upstream of the antenna window. It was thought that this could possibly be due to the impingement of the shock waves from the nozzle exit on the model. To avoid this effect on the current series of tests, the test condition was carefully chosen to make sure that the antenna window was upstream of the point of shock impingement. However, severe gouging still occurred. See Figure 76. It was suggested that the ablator, which is porous, should be sealed around the edges and on the back face to prevent leakage of gaseous ablation products through the ablative block. Accordingly, the second model to be tested was coated with RTV-60 rubber on all sides except the face exposed to the stream. No significant difference in resistance to gouging was noted. See Figure 79.

2.15.1.3 In order to determine the effect of the antenna window on the erosion of the ablator, a plain block of ablative material, without an antenna, was tested. Erosion still occurred, but the depth eroded was much less. See Figure 81. The indication seemed to be that as the ablator eroded, the end of the antenna was exposed, providing a protuberance effect which intensified the heating of the ablator on the upstream side, which in turn caused severe local erosion.

2.15.1.4 A total of four test runs were made; the three mentioned above, and a test of a Type II antenna which corresponded to Test Level No. 3 of Paragraph 4.5.7.3 of NAA Spec. MC 481-0005 Revision C. As in the original test series, a calorimeter model was used to establish the test conditions.

2.15.2 Antenna Models

2.15.2.1 The models used in these tests were production antennas, Types II and IV inserted through blocks of ablative material corresponding to their installation in the Apollo heat shield. One plain block of ablative material was also tested to investigate the effect of the antenna on the degradation of the heat shield material.

2.14.2.2 Thermocouples on these models were not embedded in the antenna, as with the previous tests. Instead they were located as follows:

t/c No. 1 - clamped in aluminum mounting flange.

t/c No. 2 - between graphite clamp and antenna body.

t/c No. 3 - cemented to back cap of antenna.

t/c No. 4 - on coaxial connector at back of antenna.

2.15.3 Calorimeter Model

2.15.3.1 The same model was used for calibration as in the previous series of tests, except that a Hy-Cal "Asymptotic" water-cooled calorimeter was installed in place of the copper slug.

2.15.4 Test Procedures

2.15.4.1 Installation

2.15.4.1.1 The model holder was similar to the one in previous tests except that the back end was enlarged to cover the antenna end cap and connector, and provision was made for water-cooling the calorimeter. In addition, a 1/8 inch asbestos insulator and nylon washers were used to reduce heat losses from the antenna mounting flange to the holder.

2.15.4.2 Operation

2.15.4.2.1 Since the minimum heat available was of the order of 21 BTU/FT^2 sec. to the surface of the model, the exact heating variations as specified in NAA Spec. MC 481-0005 Revision C could not be followed. As in the previous tests, the trajectories were approximated by a series of steady states and linear variations, with the total heat load approximately equal to that of the actual trajectory. The deviations from ideal power variation which caused errors in total heat load in the previous test series were eliminated by programming the desired variations on a semi-automatic curve follower which guided the tunnel operator in controlling power input.

2.15.4.2.2 Heating or cooling the specimen before insertion was accomplished in the same manner as for the previous tests, except that the process was continued until <u>all</u> thermocouples were at or beyond the required temperature.

2.15.5 Data Reduction

2.15.5.1 Calorimeter Data

2.15.5.1.1 Hy-Cal "Asymptotic" calorimeters have an output which is proportional to heat flux, rather than slug temperature, as with the slug-type calorimeter used previously. Computation of heat flux therefore reduces to:

$$\dot{q} = K \text{ (mv.)}, \text{ BTU/FT}^2 \text{ sec.}$$

where: (mv.) is the calorimeter output, millivolts.

K = calibration constant, BTU/FT^2 sec. mv.

For these tests, calorimeter model C-1300-A-120-072, Serial No. 14357 was used for which:

$$K = 10.78 \text{ BTU/FT}^2 \text{ sec. mv.}$$

2.15.5.2 <u>Shear Stress</u>

2.15.5.2.1 For the current tests only, an approximate level of surface shear stress was computed and is presented in Figures 74 and 82. Calculation was based on Reynold's analogy between shear stress and convective heat transfer (see Kreith, F. "Principles of Heat Transfer", International Textbook Co., 1964, p. 277 ff, or any heat transfer text). Real gas fluid properties and flow parameters were used. It must be emphasized that the results are only approximations. Not only are the quantities entering into the calculation the results of interpolations and simplifying assumptions (such as equilibrium flow), but the extent of applicability of Reynold's analogy to an ablating surface in high enthalpy flow is not known. The basic equation used was:

$$\tau = \frac{Pr^{2/3} \dot{q} V}{g \Delta H}$$

where: τ = Shear stress, LB/FT^2

$\dot{q}$ = Heat flux, BTU/FT^2 sec

V = Free-stream velocity, FT sec.

g = 32.2 FT/sec^2

ΔH = Enthalpy difference across boundry layer BTU/LB

Pr = Prandl number

2.15.5.2.2 Calculated points, based on calibration runs, showed about ± 10% scatter about a straight line faired through them in a plot of τ vs. plenum pressure, Po. The straight line was used as a basis for the plots shown in Figures 74 and 82.

2.15.6 Index of Data

2.15.6.1 Photographs and Test Data

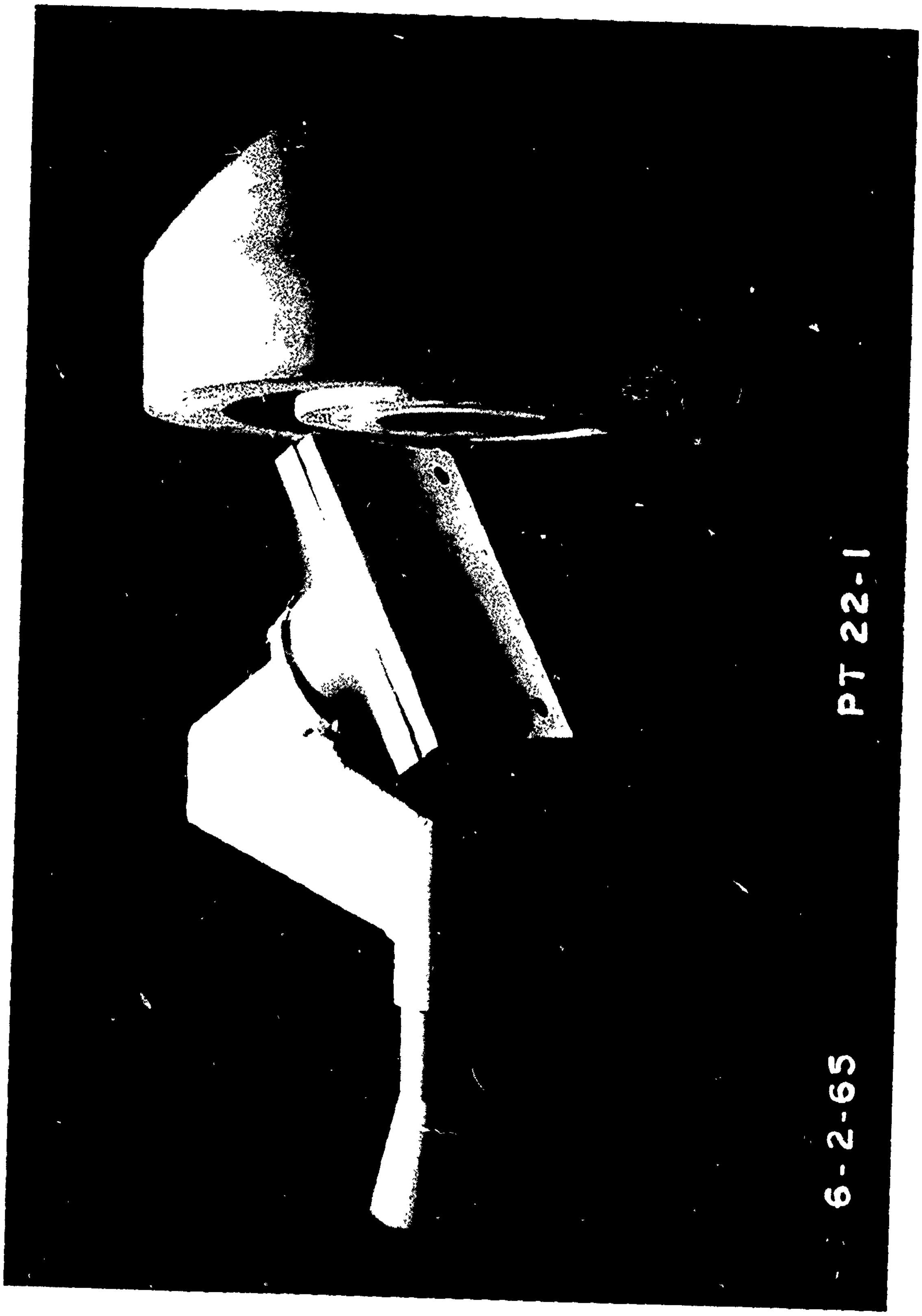

Figure 69. Calorimeter Model in Test Position - Front View

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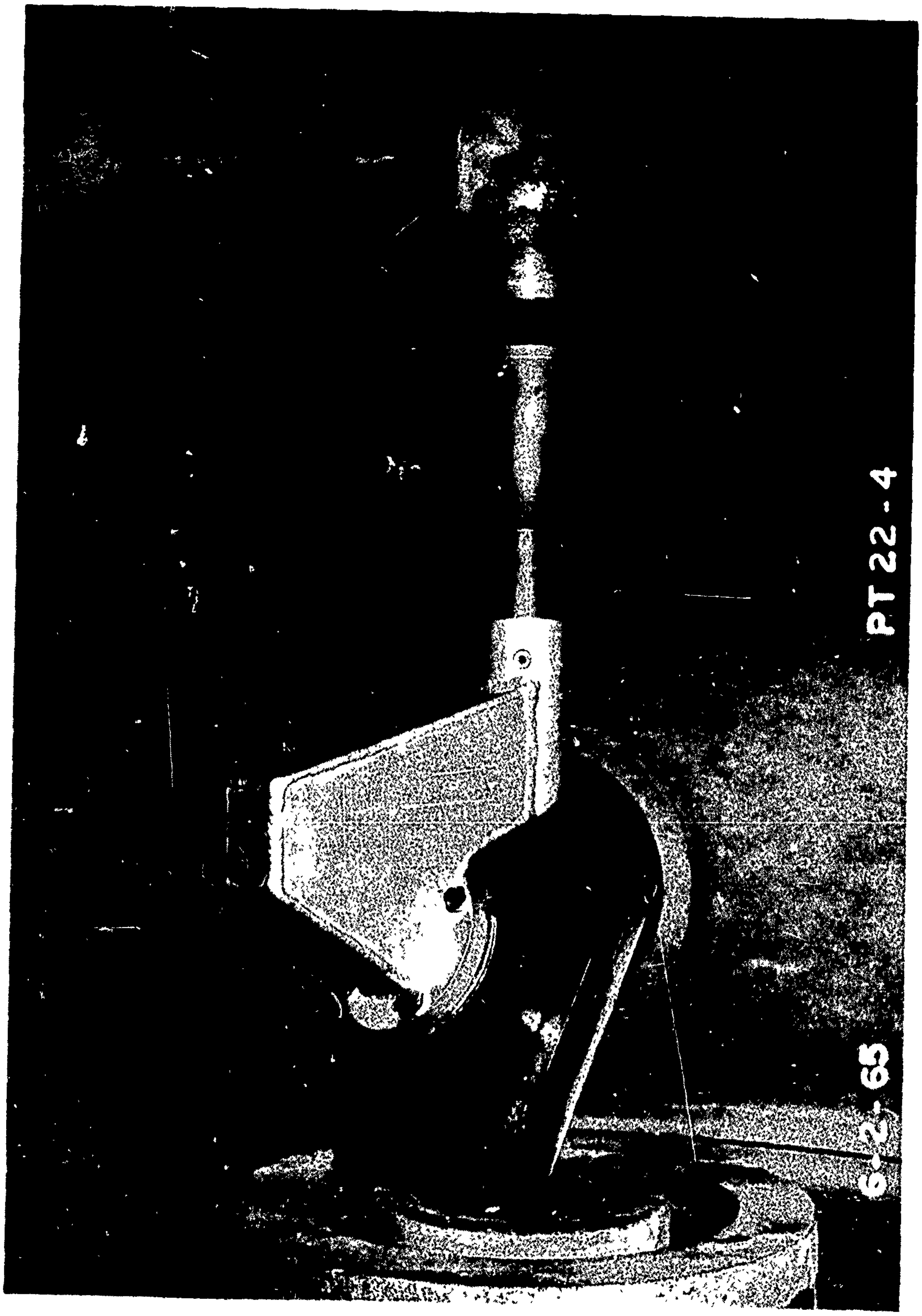

Figure 70. Calorimeter Model in Test Position - Rear View

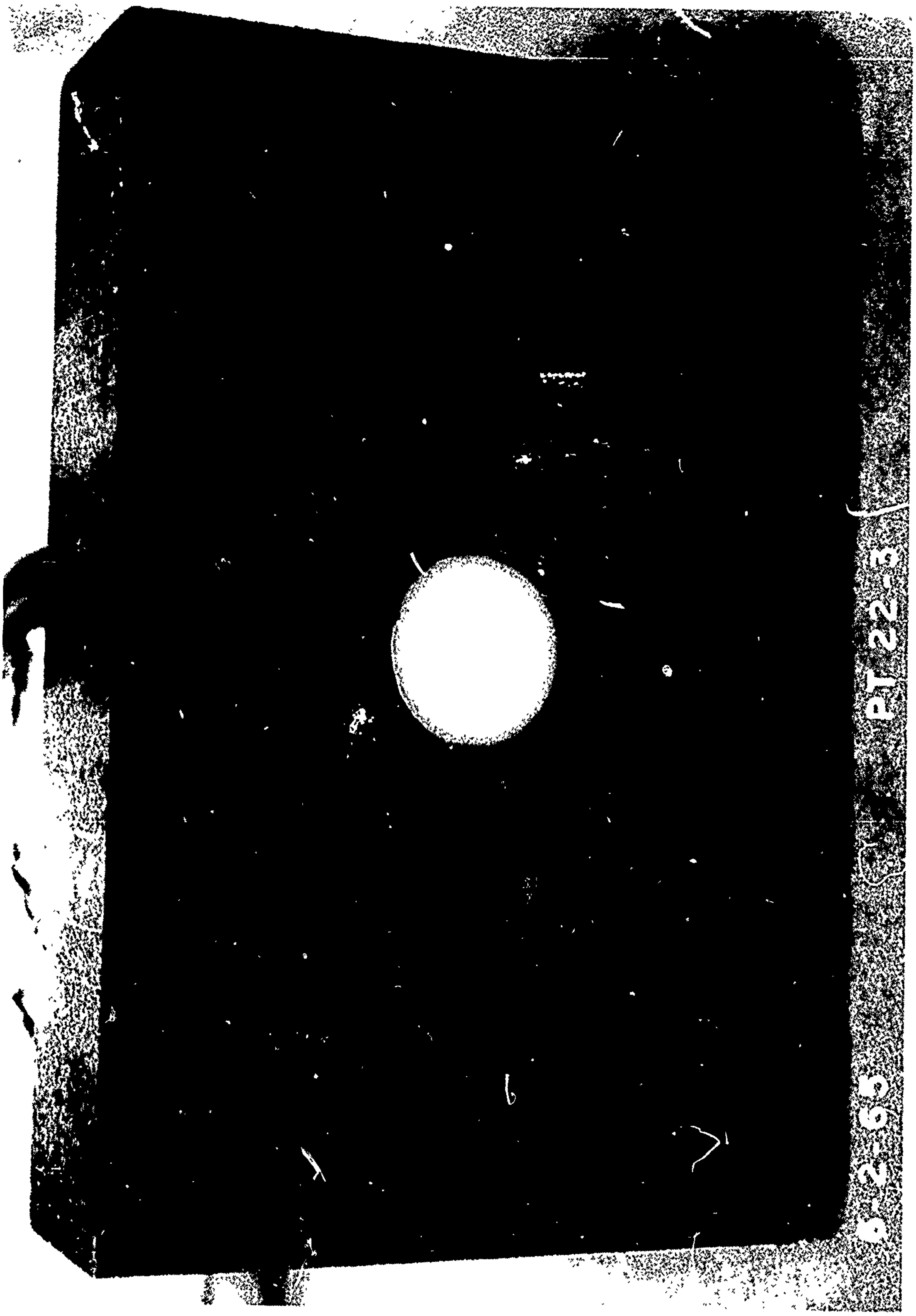

Figure 71. Face of Typical Antenna Model

DO NOT MICROFILM

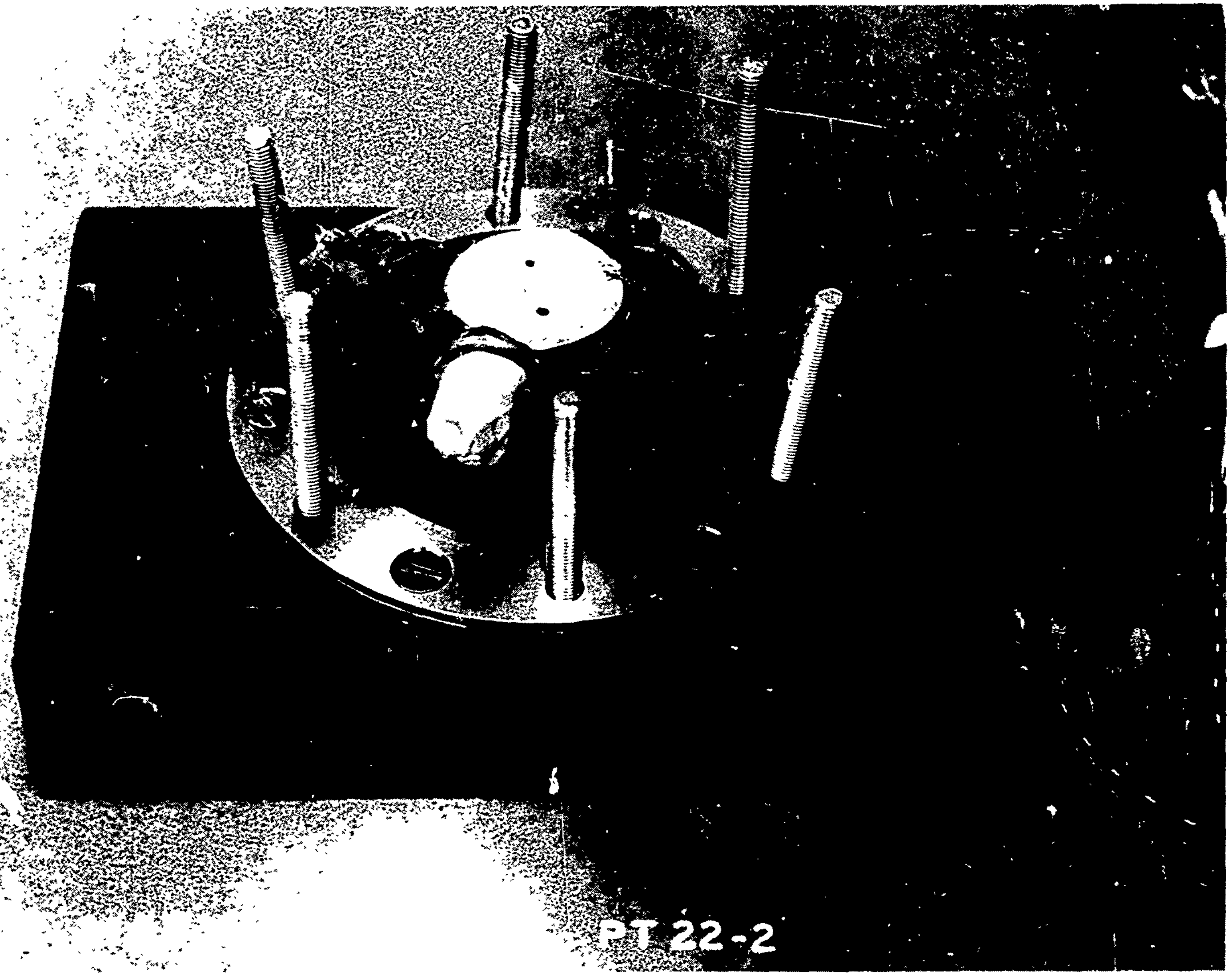

Figure 72. Rear of Type II Antenna Model

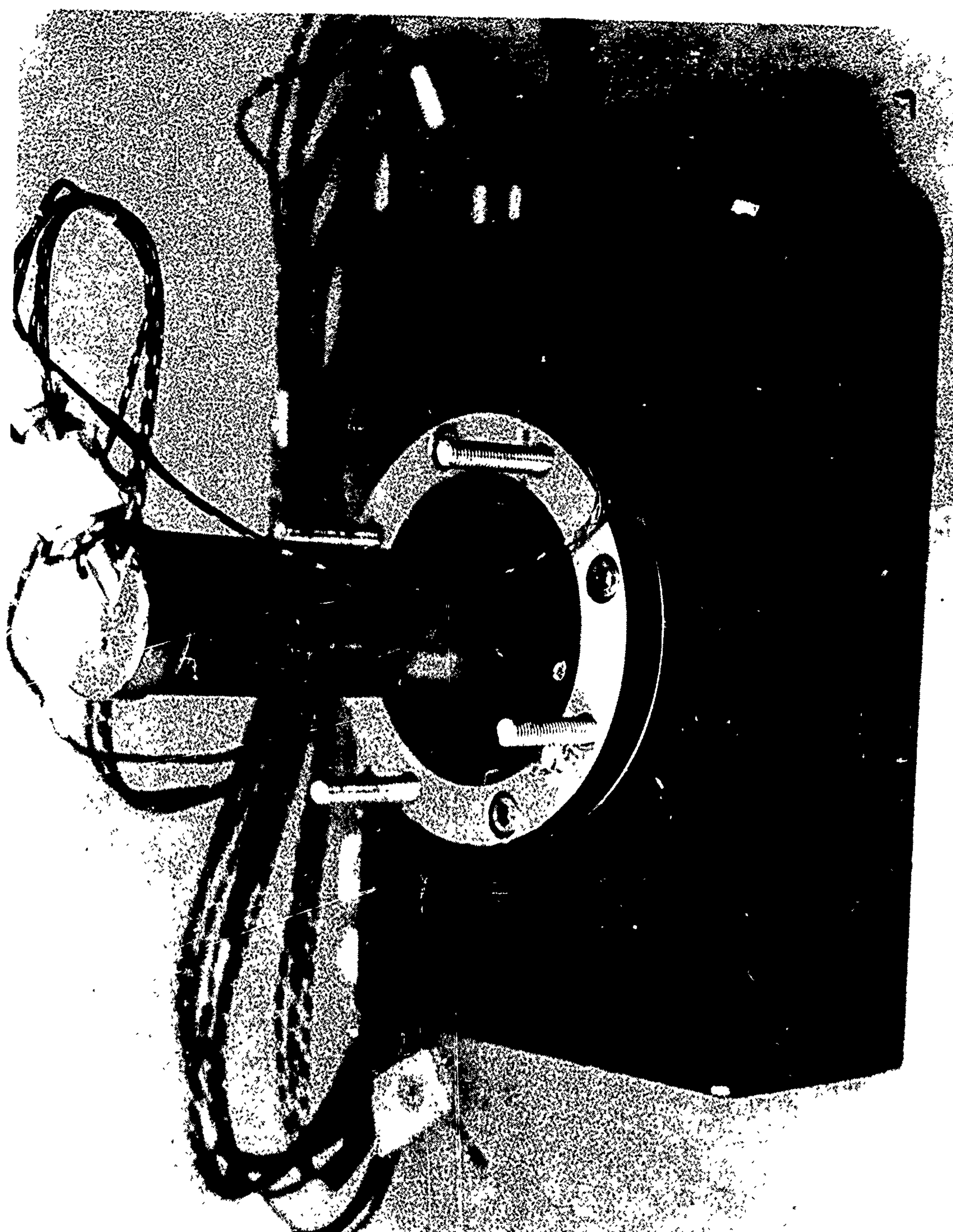

Figure 73. Rear View of Type IV Antenna Model

DO NOT MICROFILM

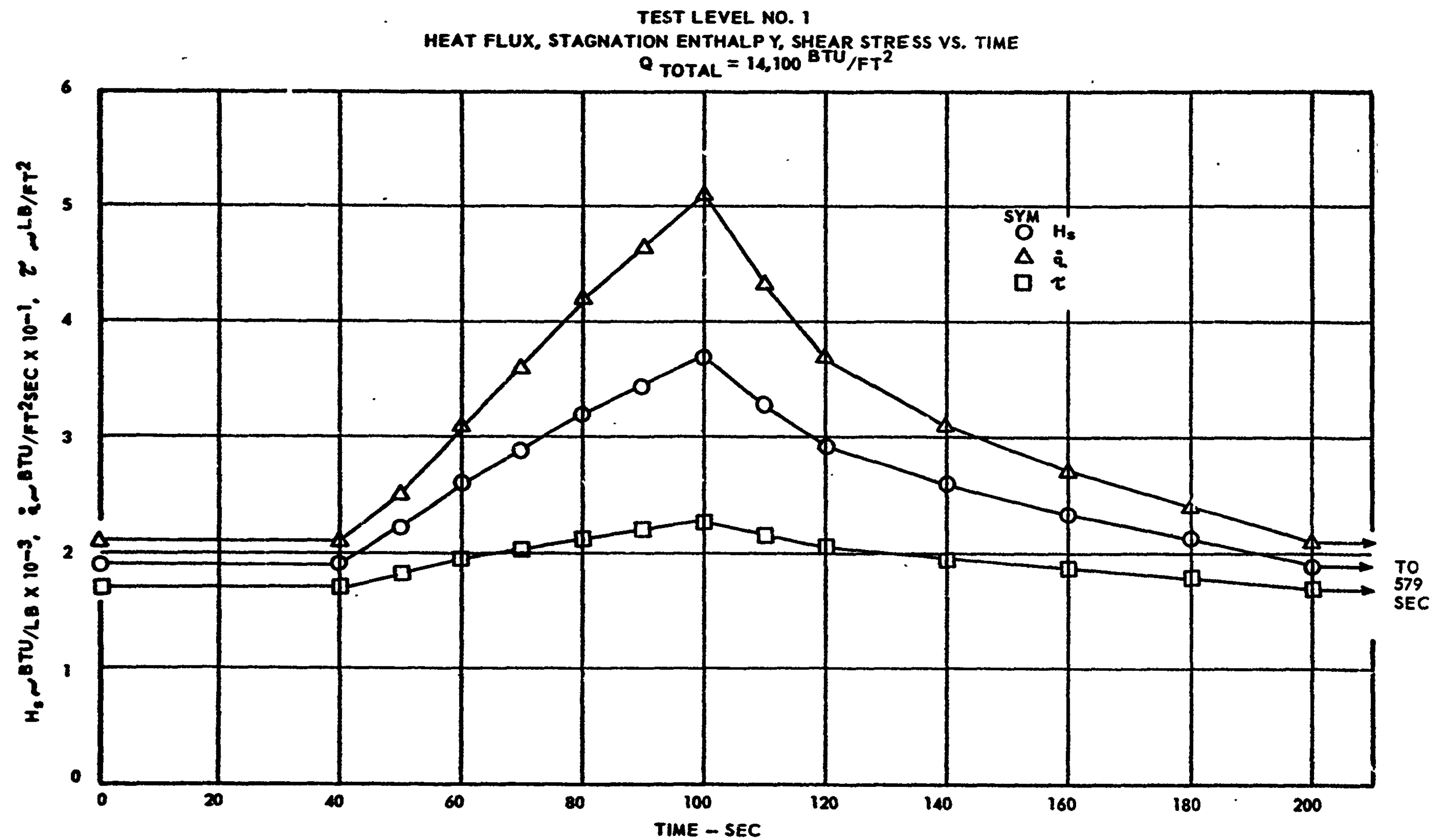

Figure 74. Hs, $\dot{q}$, and τ vs. Time - Test Level No. 1

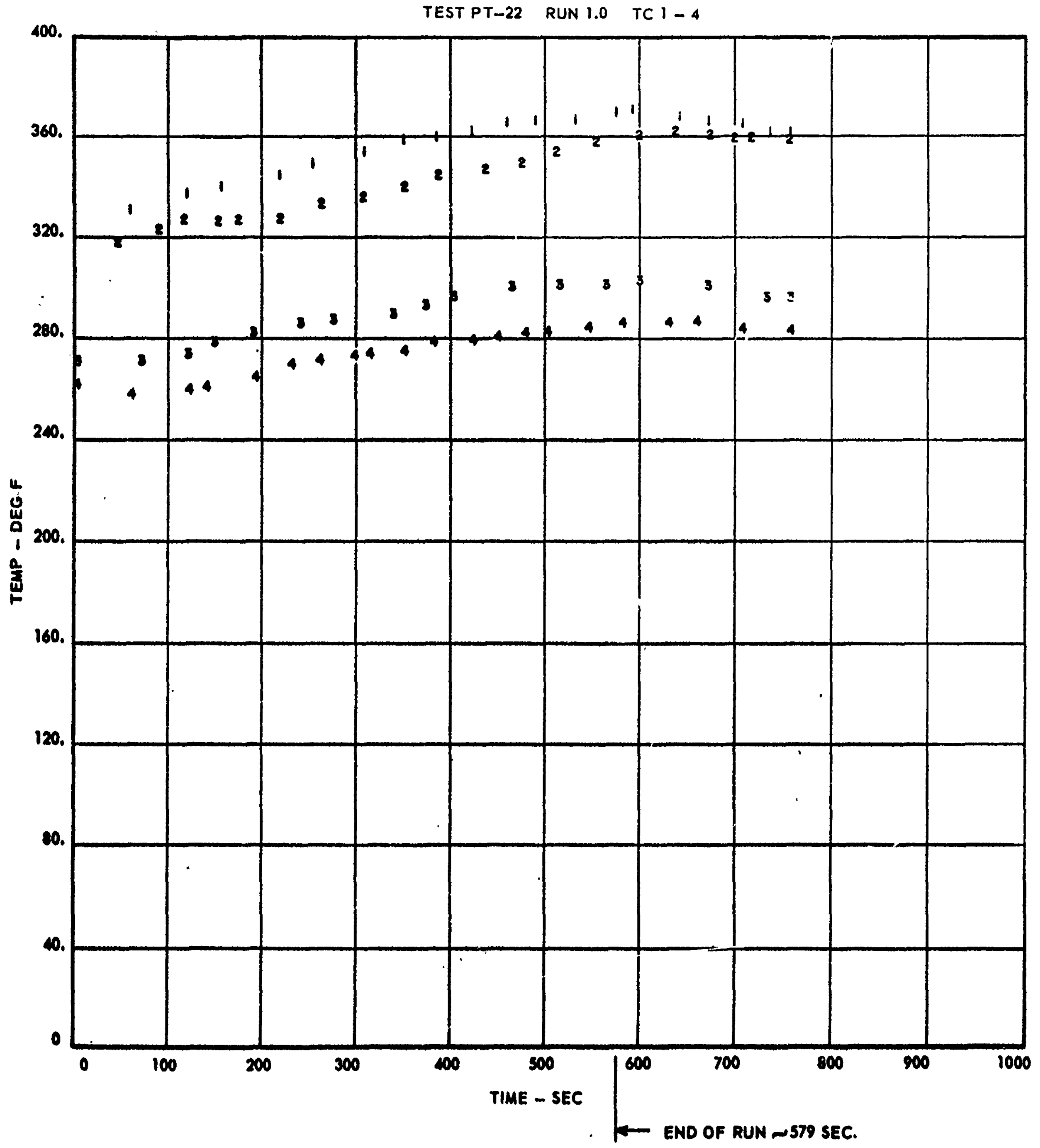

Figure 75. Temperature Distribution History (Run No. 1)

DO NOT MICROFILM

Figure 76. Type IV Antenna After Test (Run No. 1)

DO NOT MICROFILM

TEMPERATURE-TIME HISTORY

RUN 1 6-4-65

	TC 1		TC 2		TC 3		TC 4	
PT	TIME SEC	TEMP DEGF	TIME SEC	TEMP DEGF	TIME SEC	TEMP DEGF	TIME SEC	TEMP DEGF
1	0.	329	0.	325	0.	271	0.	260
2	60.27	331	43.75	318	70.34	271	60.23	258
3	120.55	337	87.49	322	119.58	274	120.46	260
4	156.71	340	116.66	327	147.72	278	138.53	260
5	216.99	344	153.11	327	189.93	282	192.74	264
6	253.15	349	174.99	327	239.17	285	228.88	269
7	307.40	353	218.73	328	274.34	287	258.99	271
8	349.59	358	262.48	333	337.65	290	295.13	273
9	385.76	360	306.23	336	372.82	293	313.20	274
10	421.92	362	349.98	340	400.96	296	349.34	275
11	458.09	365	386,43	344	464.27	300	379.46	278
12	488.22	367	437.47	347	513.51	300	421.62	279
13	530.42	367	473.93	349	562.75	301	445.71	280
14	572.61	370	510.38	353	597.92	302	475.83	282
15	590.69	371	554.13	358	668.27	300	499.92	282
16	638.91	369	597.88	360	731.58	296	542.08	284
17	669.05	367	634.33	361	755.00	296	578.22	285
18	705.21	365	670.79	360	-0.	31	626.41	286
19	735.35	362	699.95	360	-0.	31	656.52	286
20	755.00	361	714.53	360	-0.	31	704.71	283
21	-0.	31	755.00	360	-0.	31	754.40	282

Figure 77. Tabulated Data (Run No. 1)

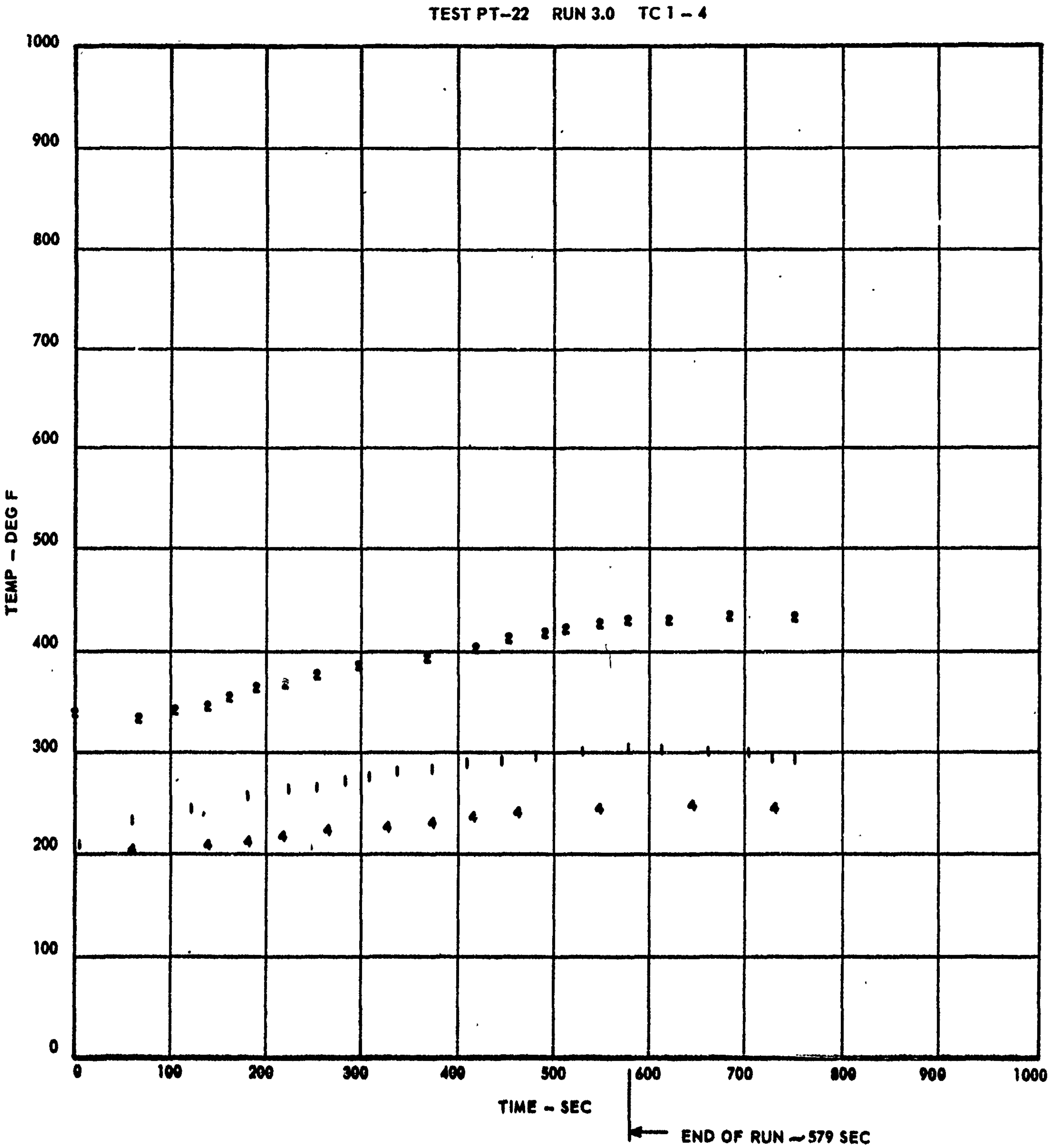

Figure 78. Temperature Distribution History (Run No. 3)

DO NOT MICROFILM

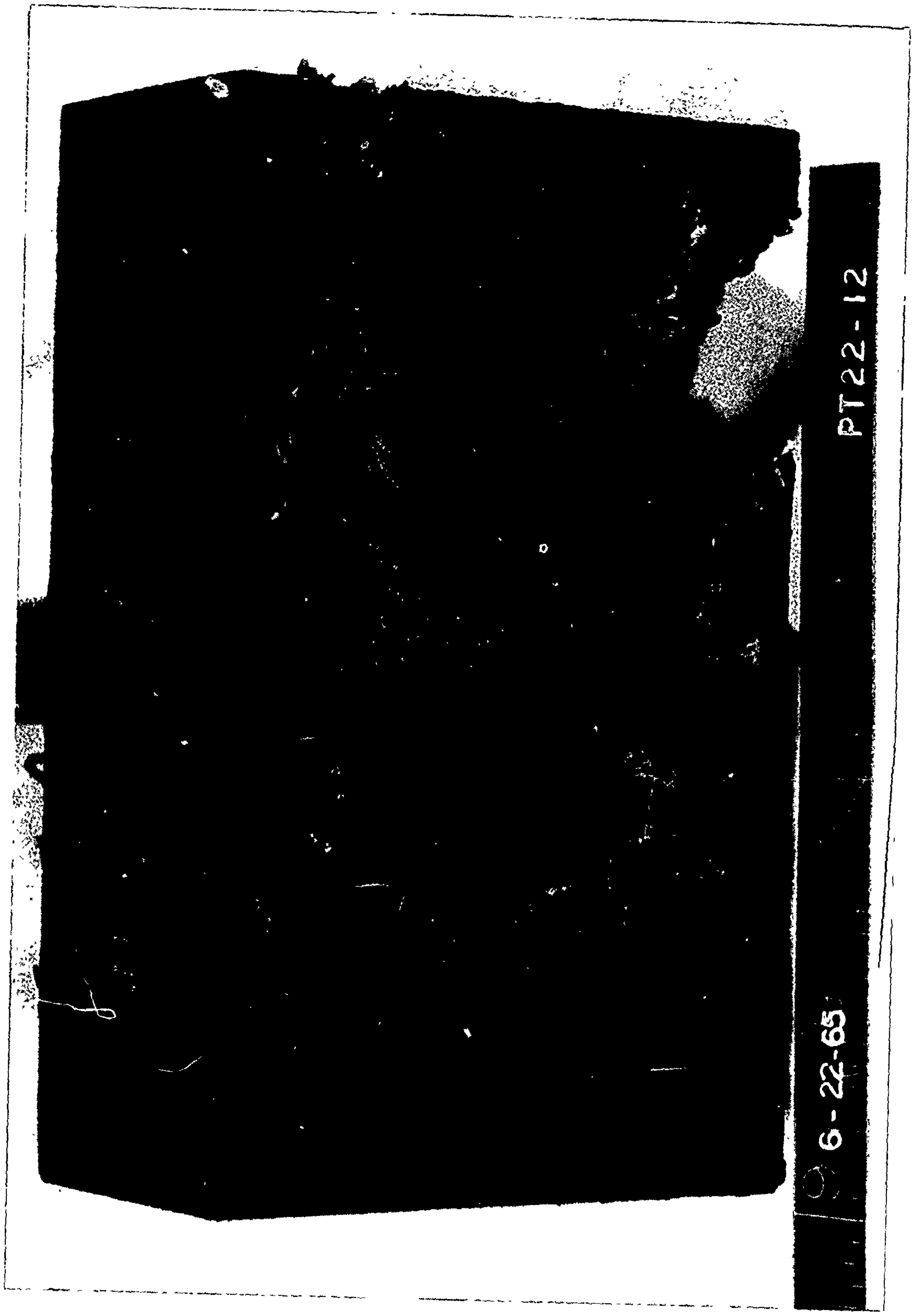

Figure 79. Type IV Antenna After Test (Run No. 3)

DO NOT MICROFILM

TEMPERATURE-TIME HISTORY

RUN 3 **6-21-65**

	TC 1		TC 2		TC 4	
PT	TIME SEC	TEMP DEGF	TIME SEC	TEMP DEGF	TIME SEC	TEMP DEGF
1	0.	230	0.	337	0.	206
2	60.05	232	66.93	331	60.03	204
3	120.10	243	102.80	340	138.07	208
4	150.12	247	138.67	344	180.09	212
5	180.14	256	160.19	353	216.10	217
6	222.18	262	188.88	362	264.13	221
7	252.20	265	217.58	367	324.16	225
8	282.23	271	253.44	376	372.18	230
9	306.24	274	296.48	385	414.20	234
10	336.27	278	368.22	394	462.22	239
11	372.30	282	418.44	403	546.26	243
12	403.33	287	454.30	412	600.29	246
13	444.36	291	490.17	416	642.31	246
14	480.38	296	511.69	421	726.35	243
15	528.42	300	547.56	426	750.00	242
16	576.46	305	576.26	430	-0.	31
17	612.49	302	619.30	430	-0.	31
18	660.53	300	683.86	434	-0.	31
19	702.56	298	750.00	432	-0.	31
20	726.58	292	-0.	31	-0.	31
21	750.00	291	-0.	31	-0.	31

Figure 80. Tabulated Data (Run No. 3)

Figure 81. Plain Ablative Block After Test (Run No. 5)

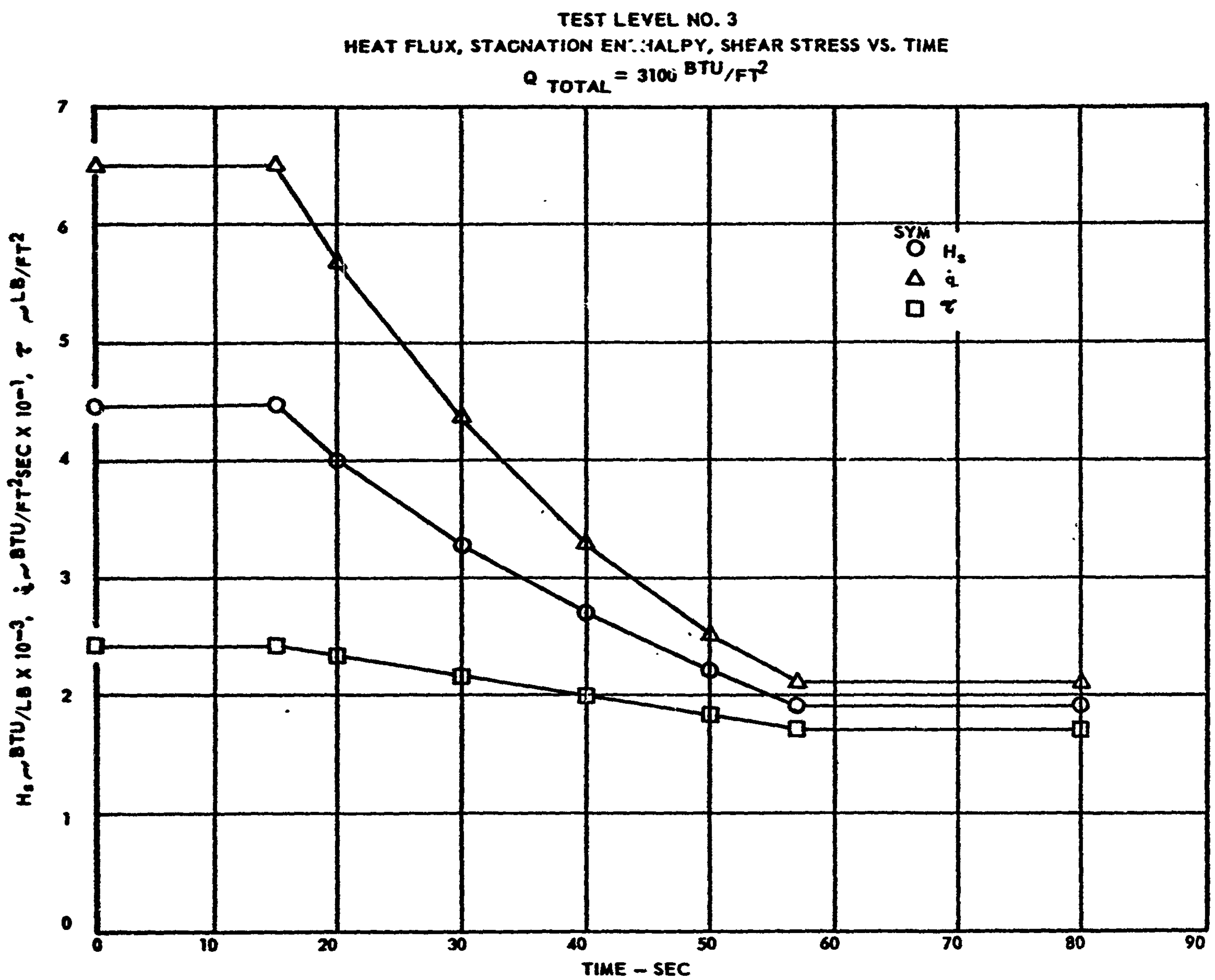

Figure 82. Hs, $\dot{q}$, and τ vs. Time - Test Level No. 3

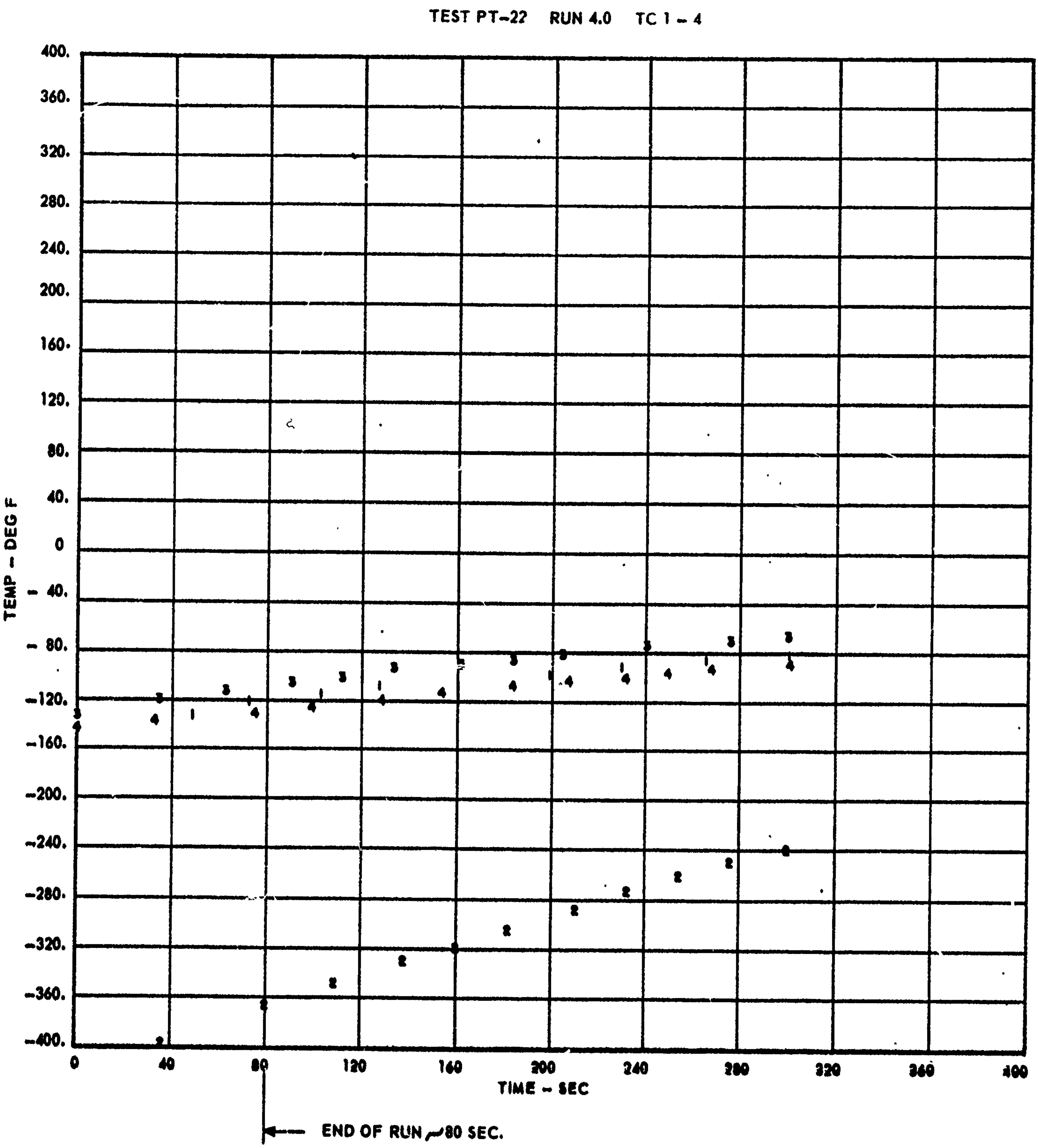

Figure 83. Temperature Distribution History (Run No. 4)

DO NOT MICROFILM

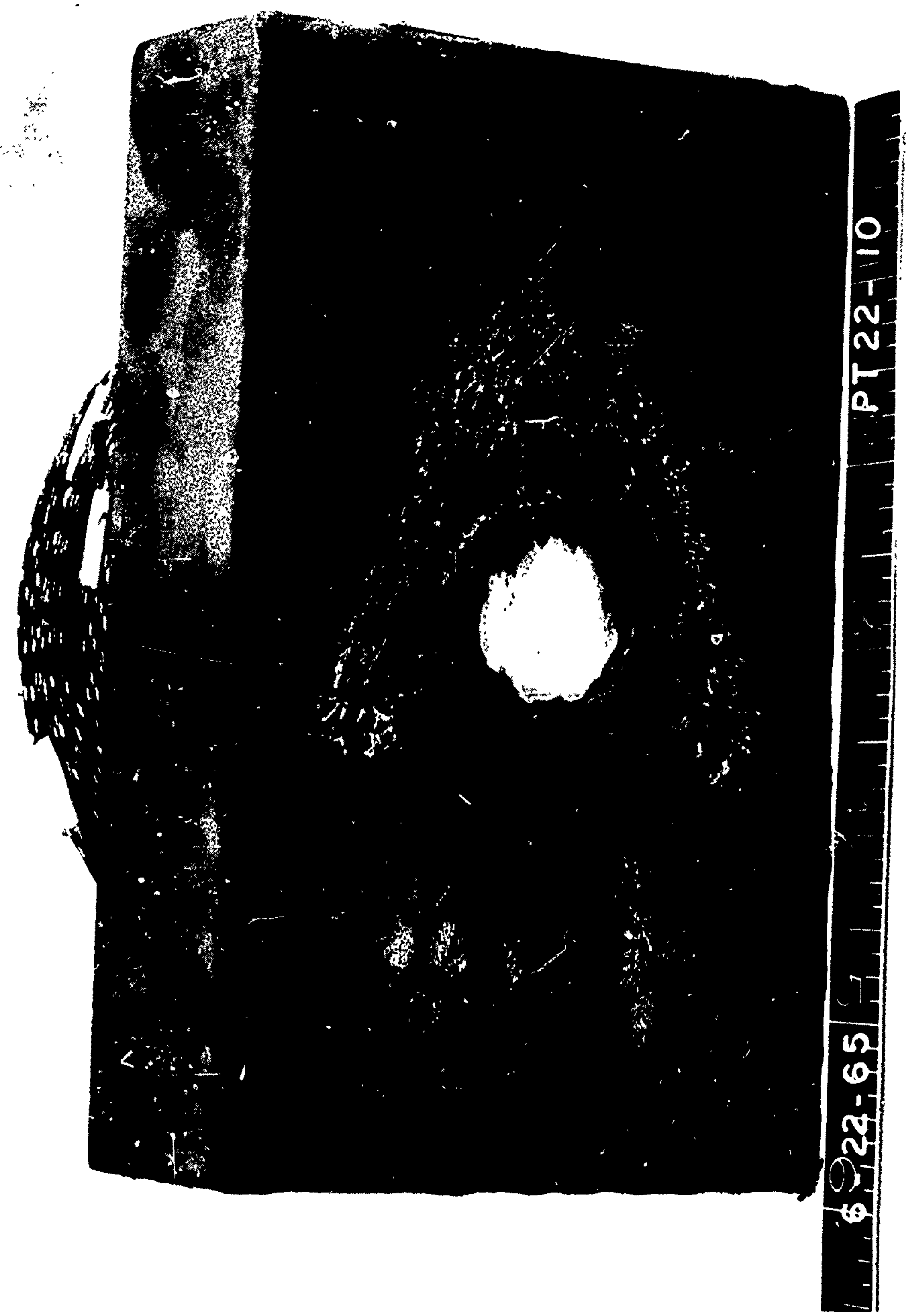

Figure 84. Type II Antenna After Test (Run No. 4)

TEMPERATURE-TIME HISTORY

RUN 4 6-21-65

PT	TC 1 TIME SEC	TC 1 TEMP DEGF	TC 2 TIME SEC	TC 2 TEMP DEGF	TC 3 TIME SEC	TC 3 TEMP DEGF	TC 4 TIME SEC	TC 4 TEMP DEGF
1	0.	-155	0.	-421	0.	-131	0.	-143
2	48.24	-134	35.40	-397	33.42	-119	32.13	-137
3	72.36	-119	80.08	-364	61.92	-113	74.32	-131
4	102.51	-114	109.20	-349	90.43	-106	98.43	-125
5	126.63	-108	138.32	-330	111.81	-101	128.57	-119
6	198.99	-97	160.16	-318	133.18	-93	152.68	-114
7	229.15	-91	181.99	-303	161.69	-89	182.82	-108
8	265.33	-86	211.11	-289	183.06	-86	206.93	-104
9	300.00	-82	232.95	-273	204.44	-80	231.04	-100
10	-0.	31	254.79	-260	240.07	-75	249.13	-97
11	-0.	31	276.63	-249	275.70	-70	267.21	-93
12	-0.	31	300.00	-239	300.00	-66	300.00	-89

Figure 85. Tabulated Data (Run No. 4)

2.15.7 Test Results

2.15.7.1 The following conclusions were made as a result of these tests:

(1) The antennas tested did meet the requirements of NAA Spec. MC 481-0005 Revision C.

(2) The antennas were checked electrically after the tests and they functioned within the acceptance requirements.

(3) The compatibility of the testing facilities at NAA/LA with the nature of the testing required for the Qualification Test Program is a problem.

(4) The tests were unacceptable as Qualification Tests but were acceptable as Development Tests. The tests were actually more severe than the requirements of the Qualification Tests.

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MAR 31 2009

Ref: 09-FC-0010,
DTIC-R 2008-30

MEMORANDUM FOR DEFENSE TECHNICAL INFORMATION CENTER
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8725 JOHN J. KINGMAN ROAD, SUITE 944
FORT BELVOIR, VA 22060-6218

SUBJECT: Freedom of Information Request (FOIA) – Mr. Scott Wengler

This is in response to your June 6, 2008, referral to the Naval Surface Warfare Center (NSWC) (copy attached) requesting that office review one document, "Apollo Beacon Antennas" AD807835, responsive to the FOIA request of Mr. Wengler. The request was transferred to this Office on October 14, 2008. The Office of the Secretary of Defense, in coordination with the National Aeronautics and Space Administration, has determined that the document may be released in full. Per your memorandum to NSWC, we are informing you of this determination so that the document's distribution statement may be changed accordingly. Our point of contact for this action is Mr. Cameron Morse, cameron.morse.ctr@whs.mil, 703-696-4699.

Paul J Jacobsmeyer
Paul J. Jacobsmeyer
Chief

Attachments:
As Stated